DESIGN REPORT FOR
PFAS SOURCE AREA
GROUNDWATER REMEDIATION PROJECT
CURRENT FIREHOUSE AND
FORMER FIREHOUSE AREAS

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U.S. Department of Energy
Brookhaven Site Office

June 2021

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June 2021

Introduction:

The past use of Aqueous Film Forming Foam (AFFF) for firefighter training at Brookhaven National Laboratory's Current Firehouse and Former Firehouse facilities has resulted in the contamination of the Upper Glacial aquifer with Per- and Polyfluoroalkyl Substances (PFAS). The objective of this document is to provide details of the plans to construct two groundwater treatment systems to control and remediate the high concentration PFAS plume segments that originate from both facilities. This document also provides a brief summary of the groundwater characterization of the two plume segments, the results of groundwater modeling, the recommended scope of treatment of and design details of each proposed remediation system.

Additional characterization to delineate the PFAS plume in downgradient areas will be performed as part of a CERCLA Remedial Investigation (RI).

Background:

PFAS is a family of substances rather than a single compound. The source areas may contain dozens of different linear and branched PFAS compounds having carbon chains of different lengths. In August 2020 New York State adopted drinking water standards (Maximum Contaminant Levels or MCLs) of 10 ng/L (parts per trillion) for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). For the new treatment systems, is anticipated that the State Pollutant Discharge Elimination System (SPDES) discharge limits for PFOA and PFOS will be equivalent to the 10 ng/L MCLs. It is anticipated that establishment of SPDES equivalent discharge limitations on a broader array of PFAS compounds will occur in the future.

Drinking water samples include analysis for six PFAS compounds ranging in chain length from four to nine carbon atoms. Environmental sampling at BNL has included over twenty different PFAS compounds ranging in chain length from four to fourteen carbon atoms. Future Unregulated Contaminant Monitoring Rule sampling for potable water systems are expected to include 29 PFAS compounds.

As a practical matter, the discharge limitations for the treated water will be based on what range of PFAS compounds is sampled for. As a broad generalization, the shorter the carbon chain length of the PFAS compound, the more rapidly that particular substance will break through the filter bed of the treatment system. Data available from another site in Suffolk County which used both Granular Activated Carbon (GAC) and a particular resin showed that the butane based PFAS compounds (PFBA and PFBS, each with a four carbon chain) were the first to break through the media bed. At this time it is anticipated that future changes in analytical requirements will impact the frequency of treatment system media changes rather than requiring different treatment system configurations or unit operations.

Characterization:

The groundwater flow regime beneath the BNL campus is well understood and carefully monitored. The locations of the PFAS contaminated groundwater and source areas are sufficiently well defined to allow placement of remediation wells to capture the core areas of the high concentration plume segments located north of Princeton Avenue even as additional investigation will be required to characterize the leading edges of the plumes.

A Time Critical Removal Action (TCRA) PFAS Plume Characterization was carried out by BNL. The goal of the TCRA PFAS Plume Characterization Project (formerly referred to as the Phase 5 Characterization Project) was to obtain the data needed to support the design of two groundwater treatment systems that will be used to remediate the segments of Upper Glacial aquifer that contain the highest levels of PFAS contamination downgradient of the current and former firehouse facilities (BNL 2020). Because the conventional granular activated carbon filtration methods used for treating PFAS are ineffective for 1,4-dioxane, samples from select temporary wells were also analyzed for this chemical.

Initial groundwater samples at the current and former firehouse areas were collected during the Phase 2 characterization effort conducted from May 2018 through January 2019. During this effort, 14 temporary Geoprobe® wells were installed. To evaluate the vertical distribution of PFAS in the aquifer, samples were collected approximately every 10 feet, for a total of 183 sample intervals. Groundwater samples for the TCRA characterization effort were collected from July 2020 through January 2021 by installing 74 temporary Geoprobe® wells and two temporary vertical profile wells installed using hollow stem auger drilling methods. Vertical profile well PFC-VP-01-2020 was installed at the same location as PFC-GP-68 to obtain deeper groundwater samples, and BGRRVP-01-2020 was installed at the location planned for PFC-GP-111 as shown on Figure 11 and Figure 18. To evaluate the vertical distribution of PFAS in the aquifer, samples were collected approximately every 10 feet, with samples collected at 745 sample intervals. 1,4-Dioxane samples were collected at 35 temporary wells, with a total of 298 sample intervals.

A total of 21 figures were developed for the TCRA PFAS Plume Characterization report and the following discussion references several of those figures. Figure 1 shows the temporary well locations and resulting delineation of the PFOS and PFOA plume south of the Current Firehouse area. The plume overlaps 1,4-dioxane at greater depths and farther to the south. This is important for placement of remediation wells and determination of pumping rates as treatment methods for PFAS removal will not be effective for 1,4 dioxane. Figure 2 shows the concentrations of 1,4-dioxane which were encountered south of the Current Firehouse area.

Vertical sections through the plume were developed to illustrate the distribution of PFOS and PFOA within the plume and to inform the location of remediation well screens in the CFH area. Six west to east sections were defined as A-A’ to F-F’ with two north to south section lines defined as G-G’ and G1-G1’ and the location of these sections are shown on Figure 1. Section views A-A’ through G1-G1’ are shown on Figures 4, 6 and 9 through 10a and 10b.

Figure 11 shows the temporary well locations and resulting delineation of the PFOS and PFOA plume south of the Former Firehouse area. The plume overlaps 1, 4-dioxane at greater depths and farther south. Figure 12 shows the concentrations of 1,4-dioxane which were encountered. Seven west to east sections were defined as H-H’ to N-N’ with one north to south section line defined as O-O’ and the location of these sections are shown on Figure 11. Section views I-I’ through O-O’ are shown on Figures 15, 18, 20 and 21.

PFAS Capture:

The current work involves remediation of the contaminated groundwater moving generally south from each site. System components will be sized with the potential for changes in groundwater capture flow rates and locations in the future. Future modifications to treatment system flow rates, media selection and disposal were also considered to allow future operational flexibility.

Groundwater remediation will be based on a pump and treat configuration. This will consist of new pumping wells located to reduce further spread of the plumes and also to capture the highest concentration areas of the plumes to remove as much PFAS mass as quickly as possible.

The characterization data was used to locate extraction wells and the precise flow rates were optimized by groundwater modeling. Existing recharge basins on site will be used both for cost effectiveness and to avoid creating new discharge locations which might shift the location of other groundwater plumes known to exist on site. The groundwater modeling runs for the CFH remediation system reflect the transfer of some of the treated water from the OU III Basin in the west to the RA V Basin in the east. All treated effluent for the FFH system will be discharged to the RA V basin.

The system design specifies the use of pressure rated PVC water main pipe with slip on gaskets ("Blue Brute") as a cost effective and time proven option. The cost of pipe installation and trench restoration is much greater than the cost of the pipe material so there is negligible incremental cost between 4-inch, 6-inch or 8-inch pipe diameter. Therefore, piping between the remediation wells and the treatment systems will be oversized to reduce pipe friction and to allow larger flow rates in the future if needed. The screens and pumps in each individual well are oversized in comparison to the modeling predictions in order to allow flow rates of up to 100 gpm per well for future operational flexibility.

The groundwater contamination emanating from each source area crosses Brookhaven Avenue as it travels south. Brookhaven Avenue contains extensive buried utilities, particularly near the Former Firehouse area. The cost of additional piping and installation is less expensive in comparison to the cost of utility crossings. Therefore, remediation well locations were shifted away from the most complex utility areas and piping runs did not necessarily follow the most direct route. In general, new piping will follow routes located within the plume boundary areas.

Total flow rates for each remediation system are dictated by the size of the filter vessels and filter media to be used. Total flow rates for each remediation system were projected at 200 to 400 gpm and were further refined during groundwater modeling. The 10 foot diameter vessels purchased for the Current Firehouse system and to be reused for the Former Firehouse system each have a nominal hydraulic capacity of 750 gpm per vessel. This results in a maximum theoretical flow rate of 750 gpm if the pair of vessels is used in series or up to 1,500 gpm if the vessels are used in parallel.

Operation of each pair of filter vessels in series will result in greater reliability and more efficient use of the carbon media as the lead vessel can be operated to saturation, changed out and then placed into the lag position. There is growing evidence that some PFAS compounds may not adhere to GAC very strongly and may desorb if the contact time with the GAC is too short. This further argues for operation of the filters in series and at less than the maximum hydraulic flow rate.

Design calculations for sizing of pumps, motors, pipes and treatment systems are contained in **Appendix A**.

Groundwater Modeling:

Groundwater modeling reports were prepared by Arcadis for each remediation system (**Appendices B** and **C)**. The BNL Regional Groundwater Flow Model was updated and a sub-regional model was prepared for each location. The impact of pumping and recharge was examined through the use of particle tracking to determine minimal flow rates to achieve plume capture concentrations of 100 ng/L or higher.

The Current Firehouse system was configured with a total of eight wells ranging from just north of the firehouse building in the source area, with six more wells within the core of the plume extending south to Princeton Avenue. The PFAS plume has a downward vertical component as it moves south. This adds a degree of complexity as 1,4-dioxane has been detected at greater depths in the southern portion of the plume and it is desired to minimize capture of the 1,4-dioxane while still capturing the high concentration portions of the PFAS plume. The flow rates for these eight wells were projected to range from 30 to 60 gpm with a total pumping rate of 360 gpm.

The Current Firehouse treatment system will discharge to the existing OU III and HP recharge basins, which currently receive treated water from the Middle Road, South Boundary and Western South Boundary remediation systems. An existing wet well and transfer pump system allows transfer of up to an additional 300 gpm of treated water eastward to the RA V recharge basin. This transfer was included in the model scenarios so an effective net increase of only 60 gpm of recharge to the OU III basins will occur.

The Former Firehouse treatment system was configured with a total of three wells all positioned in the center of the plume, ranging from just south of Brookhaven Avenue, with two more within the core of the plume extending south to Princeton Avenue. The flow rates for these three wells were projected to range from 50 to 100 gpm with a total pumping rate of 225 gpm.

Recommendations:

Based upon the results of this recent investigation, the following recommendations are made for the Current Firehouse PFAS Groundwater Treatment System, the Former Firehouse PFAS Groundwater Treatment System and groundwater monitoring program:

- Install eight new extraction wells in the Upper Glacial aquifer to capture and treat the PFAS observed in the Current Firehouse plume and to prevent continued southerly migration. The screen depths are indicated below. These wells will be grouped with two in the source area, plus three each in two lines transecting the plume farther south along the direction of groundwater flow. The three wells located on Princeton Avenue are an alternate in the bid and the decision to install them will be based upon the costs in the winning bid.
- Install three new extraction wells in the Upper Glacial aquifer to capture and treat the PFAS observed in the Former Firehouse plume and to prevent continued southerly migration. The screen depths are indicated below. These wells will be grouped with one in the source area, plus one each at two locations to transect the plume farther south along the direction of groundwater flow.
- Install additional monitoring wells to enable monitoring of plume movement and reduction during the course of remediation. The characterization of the leading edge of the plume segments located south of Princeton Avenue will be conducted at a later date.

The table below is a summary of the rationale for the 11 new extraction wells:

Proposed Extraction Well ID	Screen Interval (ft below land surface)	Rationale
CF-RW-A	48’ – 68’	Capture PFAS concentrations within the plume source area
CF-RW-B	54’ – 74’	Capture PFAS concentrations within the plume source area
CF-RW-C	117’ – 137’	Capture PFAS concentrations near the plume western edge
CF-RW-D	70’ – 90’	Capture PFAS concentrations near the plume western edge
CF-RW-E	132’ – 152’	Capture PFAS concentrations near the plume eastern edge
CF-RW-F	121’ – 141’	Capture PFAS concentrations near the plume western edge
CF-RW-G	88’ – 108’	Capture PFAS concentrations at the plume core
CF-RW-H	98’ – 118’	Capture PFAS concentrations near the plume eastern edge
FF-RW-A	44’ – 64’	Capture PFAS concentrations near the plume source area
FF-RW-B	83’ – 103’	Capture PFAS concentrations at the plume core
FF-RW-C	104’ – 124’	Capture PFAS concentrations at the plume core

The new extraction wells will be sampled weekly for the first four weeks of operation and then put on a monthly sampling schedule for the remainder of the first year of operation. In the second year they will be sampled on a quarterly schedule. Discharge from the treatment systems will be monitored in accordance with the SPDES Equivalency Permit for the Current Firehouse and Former Firehouse Systems. Applications for these permits will be submitted by BNL.

New monitoring wells will be constructed in order to supplement the network of existing monitoring wells. The monitoring well network is configured to enable monitoring of the plume perimeter and plume core at various depths in order to verify the effectiveness of the remediation systems. Figure 1a shows the proposed locations of fifty-four new monitoring wells for the Current Firehouse remediation system. Figure 11a shows the proposed locations of twenty-nine new monitoring wells for the Former Firehouse remediation system.

Construction:

The thirty-three design drawings provide the detailed information for the installation and construction of the new extraction wells, pipelines, buildings, filters, electrical power and control and communications associated with this project. Drawing numbers include “CF” as an abbreviation for Current Firehouse and “FF” as an abbreviation for the Former Firehouse.

Drawing T-1 is the Title sheet showing the location of the projects and the drawing index. **Drawing SP-1** is a Site Plan which shows the location of the Current Firehouse and Former Firehouse plumes within the BNL campus and summary tables of the new remediation well dimensions.

Drawings S-1CF through S-5CF are Site Plans which shows the location of the new extraction wells, piping, and conduit in the Current Firehouse source area and in the plume farther south and details of the connections to existing Building 492 infrastructure and treatment system. **Drawings E-1CF through E-5CF** show the electrical details and changes required to supply power to the new wells and for connection to Building 492 and the existing BNL communications system, including the control panel view screens. **Drawings M-1CF, M-2CF and M-3CF** show the mechanical and piping details for connection to the treatment system located within Building 492 and minor changes to the building itself.

Drawings S-1FF through S-5FF are Site Plans which shows the location of the new extraction wells, piping, conduit and details of the connections to the existing GAC filter vessels located near the existing RA V recharge basin. **Drawings A-1FF and A-2FF** show details of the new metal frame building to enclose the existing GAC filter vessels. **Drawings E-1FF through E-5FF** show the electrical details and changes required to supply power to the three new wells south of the Former Firehouse and within the new GAC building and connections to Building 598 and the existing BNL communications system, including the control panel view screens.

Drawing E-6 shows electrical transformer details common to the power drops for both treatment systems. **Drawings M-4 and M-5** show the well vault mechanical, structural and piping details, as well as utility crossing piping and paving details common to both treatment systems.

Drawing W-1 shows typical well construction details for the extraction wells and vault interior components details common to both treatment systems as well as typical monitoring well details. **Drawings CC-1 and CC-2** show the electrical power, controls and communications details required to connect each well and treatment system to the existing BNL communications system.

The Current Firehouse extraction wells will have 5 horsepower 480 volt three phase motors and pumps capable of flow rates of 100 gpm and greater. The extraction wells will be completed below grade within vaults and be accessible by way of lockable hatches. New electrical and communications wiring will also be run from the new extraction wells to Building 492 and tied into the existing electric and communications systems.

Building 492 infrastructure will be reused including the electrical service, transformer, and lighting; while the interior treated and untreated water piping will be new and the dual 20,000 pound granular activated carbon vessels will be furnished by BNL as shown on **Drawing M-1CF**. The water from the eight Current Firehouse remediation wells will be transmitted through new piping to the filters in Building 492. The treated water will be piped east through new piping that ties into a run of existing piping that extends south to the OU III recharge basins.

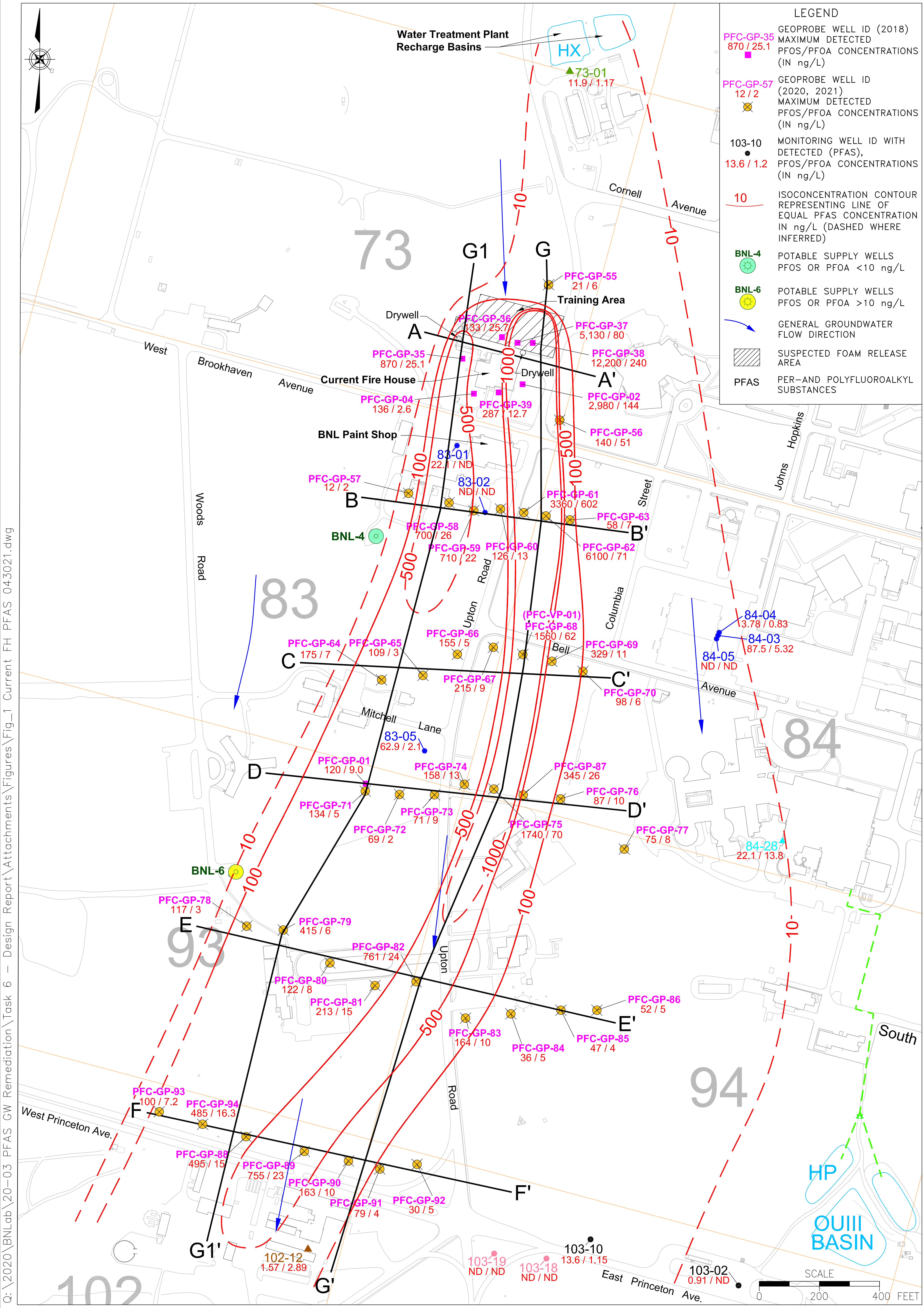
The three wells for the Former Firehouse remediation system will each have 7.5 horsepower, 480 volt motors, also capable of flow rates of 100 gpm or greater. The extraction wells will be completed below grade within vaults and be accessible by way of lockable hatches. The water from the three Former Firehouse remediation wells will be transmitted through new piping and tied into existing piping originally installed for the HFBR Tritium Pump and Recharge System. That piping runs to the existing GAC filters west of the RA V recharge basin. The GAC filter vessels will be rehabilitated and will have a steel frame building erected to enclose them. The treated water will be piped east a short distance into the RA V recharge basin.

New electrical and communications wiring will also be run from the new extraction wells to Building 749 (located south of NSLS 2) and tied into the existing BNL communications network. The new GAC building will also have a connection to the BNL communications system.

By utilizing existing Building 492, renovating the existing RA V GAC vessels and connecting to existing water lines, significant time and cost savings can be realized. Construction is expected to begin in July 2021. BNL will provide updates during construction as part of the routine Interagency Agreement teleconferences. A SPDES Equivalency permit application will be submitted to the NYSDEC for approval six months before the start of routine operations for each of the new treatment system discharges.

Work for the Current Firehouse remediation system was split into the “Source Area” which included the treatment system, building modifications and the northern-most five remediation wells and piping. The three downgradient extraction wells on Princeton Avenue will be an alternate in the bid.

FIGURES and PLANS



BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

CURRENT FIREHOUSE PFAS PLUME

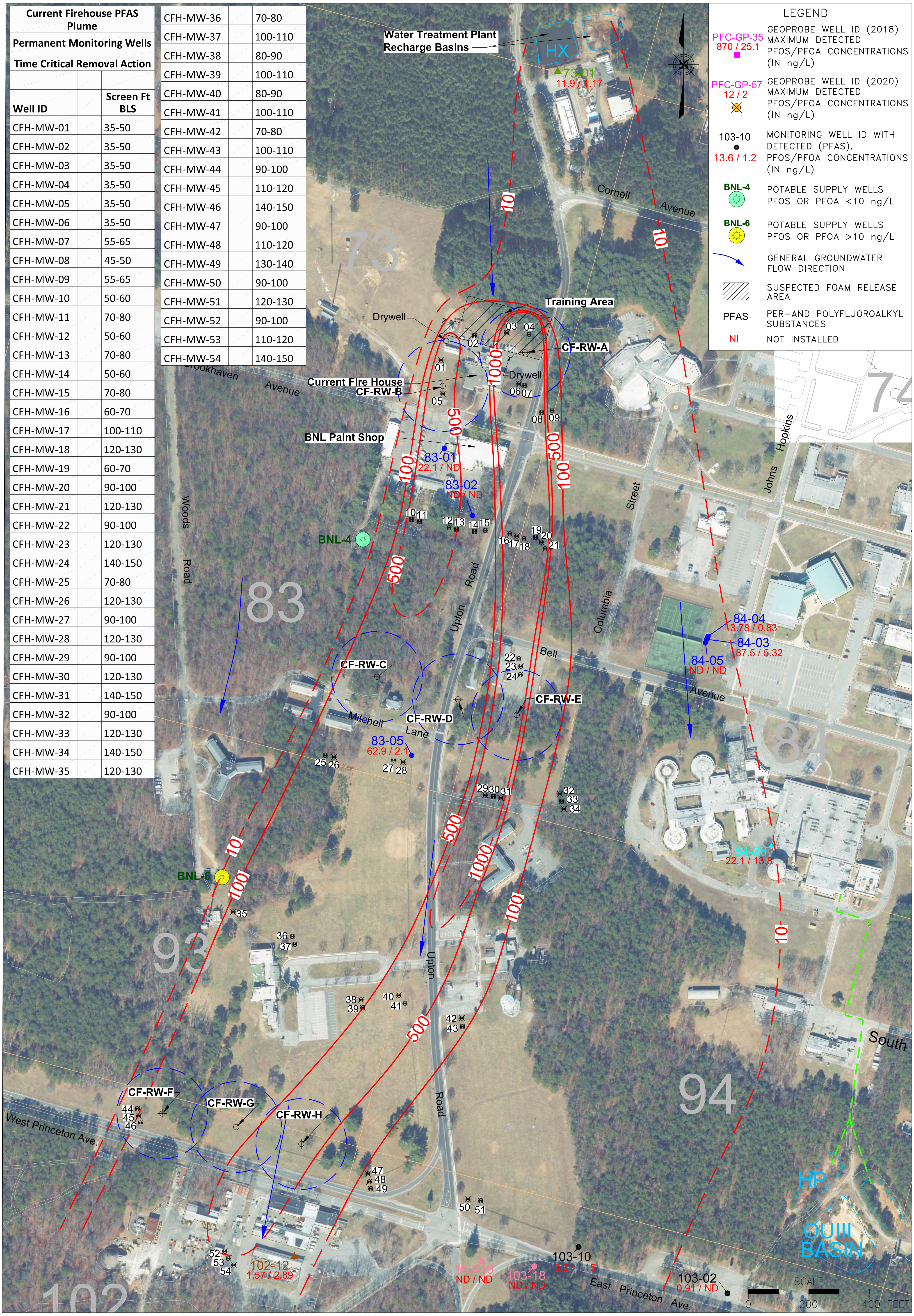
TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	—	06/17/20	—
CHKD:	APPD:	REV.:	NOTES:
DEP	DEP	04/30/21	—

FIGURE NO.: 1

Current Firehouse PFAS Plume	
Permanent Monitoring Wells	
Time Critical Removal Action	
Well ID	Screen Ft BLS
CFH-MW-01	35-50
CFH-MW-02	35-50
CFH-MW-03	35-50
CFH-MW-04	35-50
CFH-MW-05	35-50
CFH-MW-06	35-50
CFH-MW-07	55-65
CFH-MW-08	45-50
CFH-MW-09	55-65
CFH-MW-10	50-60
CFH-MW-11	70-80
CFH-MW-12	50-60
CFH-MW-13	70-80
CFH-MW-14	50-60
CFH-MW-15	70-80
CFH-MW-16	60-70
CFH-MW-17	100-110
CFH-MW-18	120-130
CFH-MW-19	60-70
CFH-MW-20	90-100
CFH-MW-21	120-130
CFH-MW-22	90-100
CFH-MW-23	120-130
CFH-MW-24	140-150
CFH-MW-25	70-80
CFH-MW-26	120-130
CFH-MW-27	90-100
CFH-MW-28	120-130
CFH-MW-29	90-100
CFH-MW-30	120-130
CFH-MW-31	140-150
CFH-MW-32	90-100
CFH-MW-33	120-130
CFH-MW-34	140-150
CFH-MW-35	120-130

CFH-MW-36	70-80
CFH-MW-37	100-110
CFH-MW-38	80-90
CFH-MW-39	100-110
CFH-MW-40	80-90
CFH-MW-41	100-110
CFH-MW-42	70-80
CFH-MW-43	100-110
CFH-MW-44	90-100
CFH-MW-45	110-120
CFH-MW-46	140-150
CFH-MW-47	90-100
CFH-MW-48	110-120
CFH-MW-49	130-140
CFH-MW-50	90-100
CFH-MW-51	120-130
CFH-MW-52	90-100
CFH-MW-53	110-120
CFH-MW-54	140-150



LEGEND

PFC-GP-35 870 / 25.1	GEOPROBE WELL ID (2018) MAXIMUM DETECTED PFOS/PFOA CONCENTRATIONS (IN ng/L)
PFC-GP-57 12 / 2	GEOPROBE WELL ID (2020) MAXIMUM DETECTED PFOS/PFOA CONCENTRATIONS (IN ng/L)
103-10 13.6 / 1.2	MONITORING WELL ID WITH DETECTED (PFAS), PFOS/PFOA CONCENTRATIONS (IN ng/L)
BNL-4	POTABLE SUPPLY WELLS PFOS OR PFOA <10 ng/L
BNL-6	POTABLE SUPPLY WELLS PFOS OR PFOA >10 ng/L
	GENERAL GROUNDWATER FLOW DIRECTION
	SUSPECTED FOAM RELEASE AREA
PFAS	PER-AND POLYFLUOROALKYL SUBSTANCES
NI	NOT INSTALLED

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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

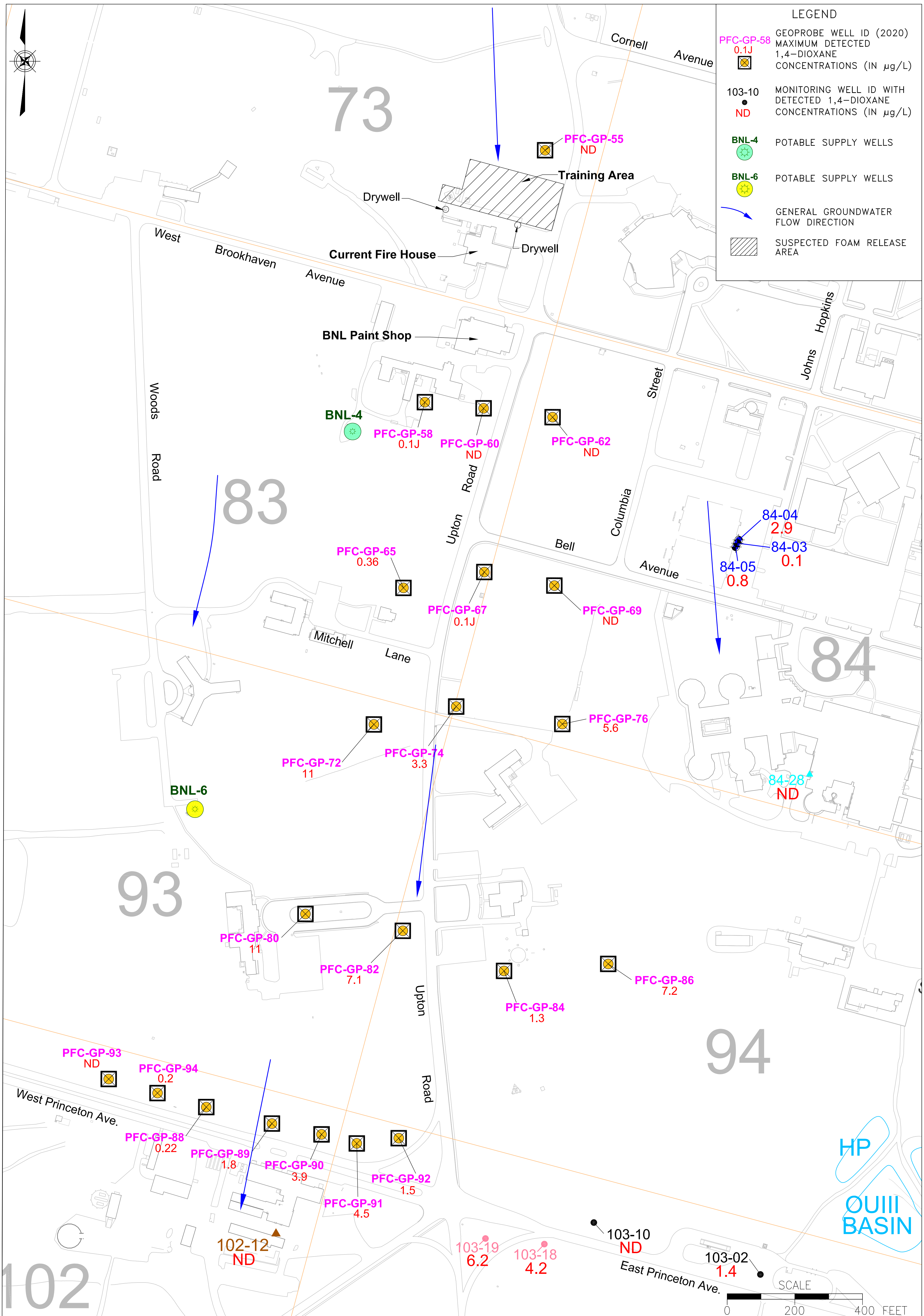
TITLE:

CURRENT FIREHOUSE PROPOSED MONITORING WELL LOCATIONS

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	—	06/17/20	—
CHKD:	APPD:	REV.:	NOTES:
DEP	DEP	05/10/21	—

FIGURE NO.: 1a



BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

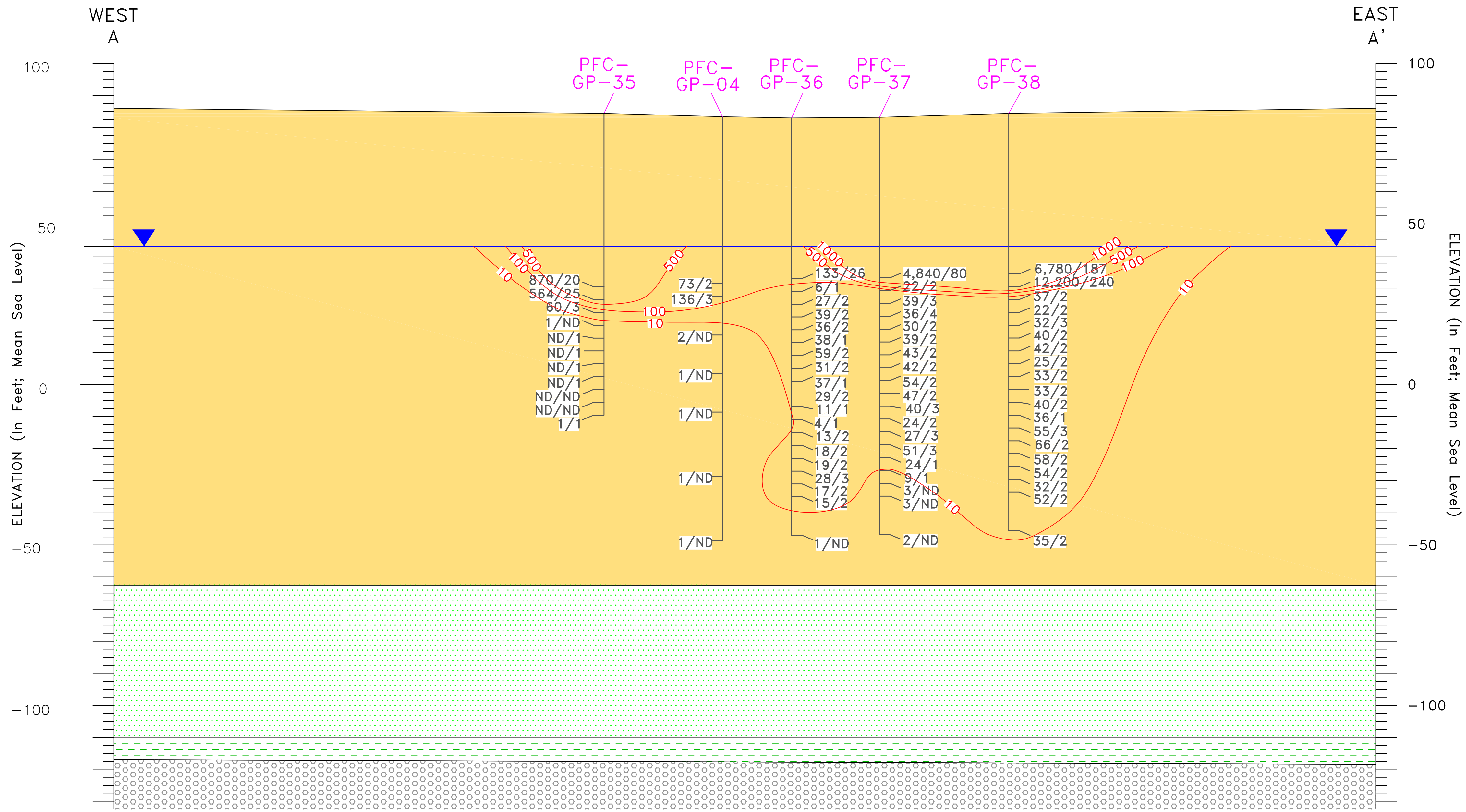
TITLE:

CURRENT FIREHOUSE 1,4-DIOXANE RESULTS

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	06/17/20	–
CHKD:	APPD:	REV.:	NOTES:
DEP	DEP	04/30/21	–

FIGURE NO.: 2



LEGEND

Upper Glacial aquifer

UG Upper Glacial Sands

UC Upper Glacial Silts & Clays

UU Upton Unit

Gardiners Clay

GL Gardiners Clay

GS Gardiners Clay - Silt

Magothy aquifer

MA Magothy Sands and Clay

MB Magothy Brown Clay

MC Magothy Clays (undiff)

MO Magothy - OTHER

HORIZONTAL SCALE

0 100 200 FEET

PFC-GP-04 Geoprobe Well ID

40/2 PFOS Value/PFOA Value in ng/L

NS = Well Not Sampled

ND = Not Detected

10 ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 - Jan. 10. 2020

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, MORE DETAILED REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 - JANUARY 26, 2021 SAMPLING EVENTS.

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BROOKHAVEN NATIONAL LABORATORY

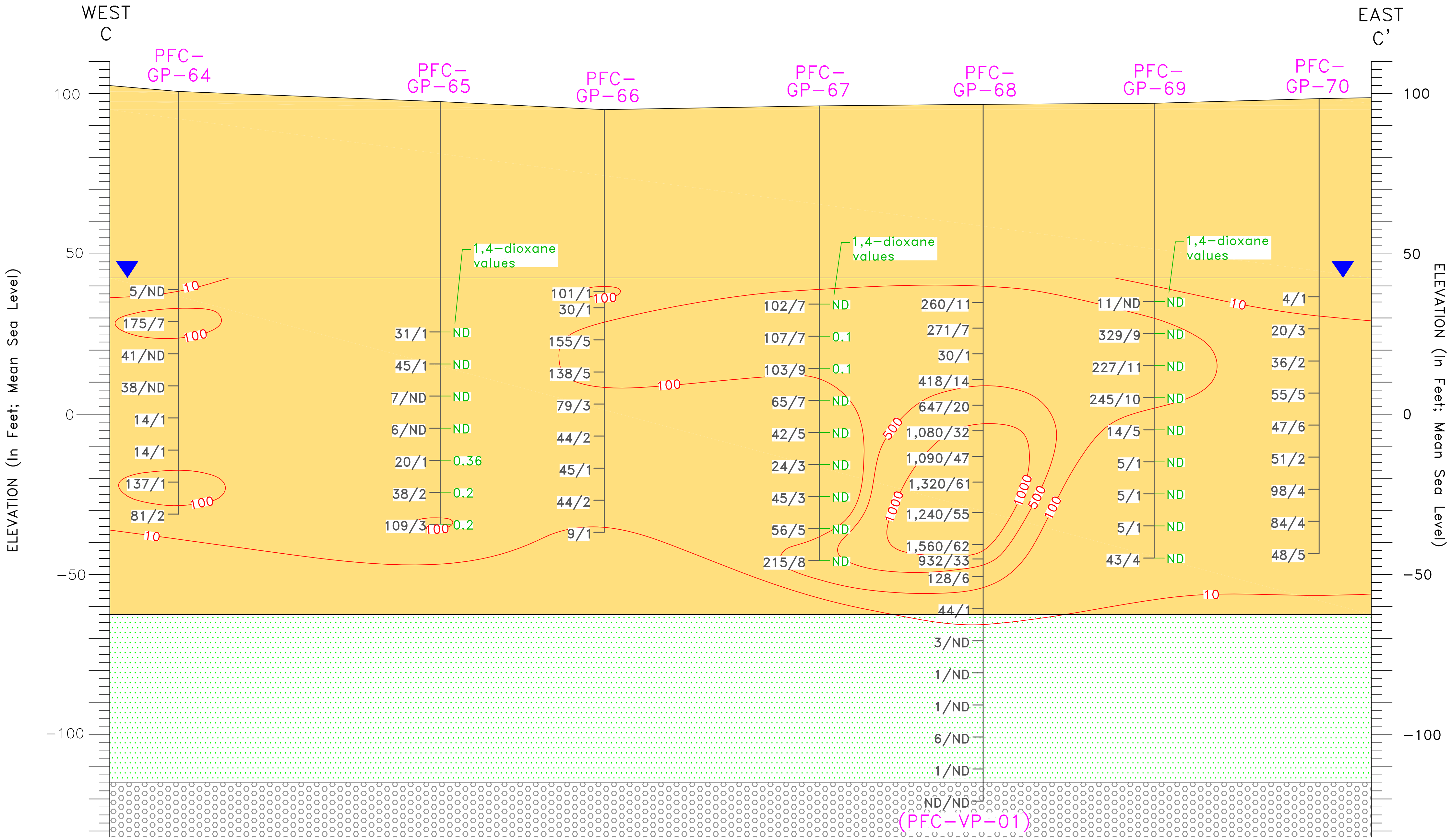
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

CURRENT FIREHOUSE CROSS SECTION A-A'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 2:1	DATE: 06/24/19	PROJECT NO.: -
CHKD: DEP	APPD: WRD	REV.: 02/11/21	NOTES: -
FIGURE NO.: 4			



LEGEND

Upper Glacial aquifer
- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay
- GL Gardiners Clay
- GS Gardiners Clay − Silt

Magothy aquifer
- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undiff)
- MO Magothy − OTHER

HORIZONTAL SCALE
0 100 200 FEET

PFC−GP−64 Geoprobe Well ID

40/2 PFOS Value/PFOA Value in ng/L

NS = Well Not Sampled
ND = Not Detected

10 ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 − Jan. 10. 2020

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, MORE DETAILED REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 − JANUARY 26, 2021 SAMPLING EVENTS.

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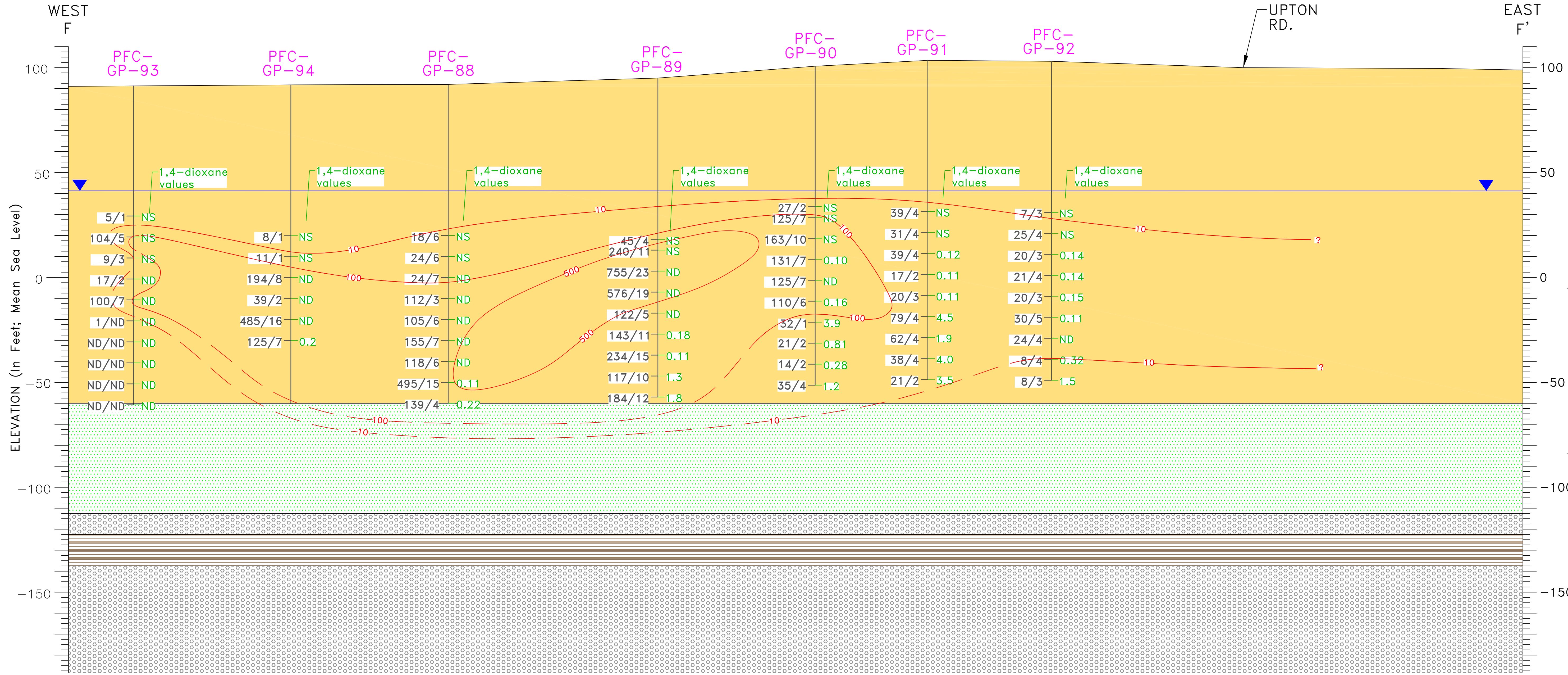
BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:
CURRENT FIREHOUSE CROSS SECTION C−C' RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 2:1	DATE: 06/24/19	PROJECT NO.: −
CHKD: DEP	APPD: WRD	REV.: 04/05/21	NOTES: −
FIGURE NO.: 6			



LEGEND

Upper Glacial aquifer

UG Upper Glacial Sands

UC Upper Glacial Silts & Clays

UU Upton Unit

Gardiners Clay

GL Gardiners Clay

GS Gardiners Clay - Silt

Magothy aquifer

MA Magothy Sands and Clay

MB Magothy Brown Clay

MC Magothy Clays (undiff)

MO Magothy - OTHER

HORIZONTAL SCALE

0 100 200 FEET

PFC-GP-88 Geoprobe Well ID

40/2 PFOS Value/PFOA Value in ng/L

NS = Well Not Sampled

ND = Not Detected

10 ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 - Jan. 10. 2020

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, MORE DETAILED REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 - JANUARY 26, 2021 SAMPLING EVENTS.

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BROOKHAVEN NATIONAL LABORATORY

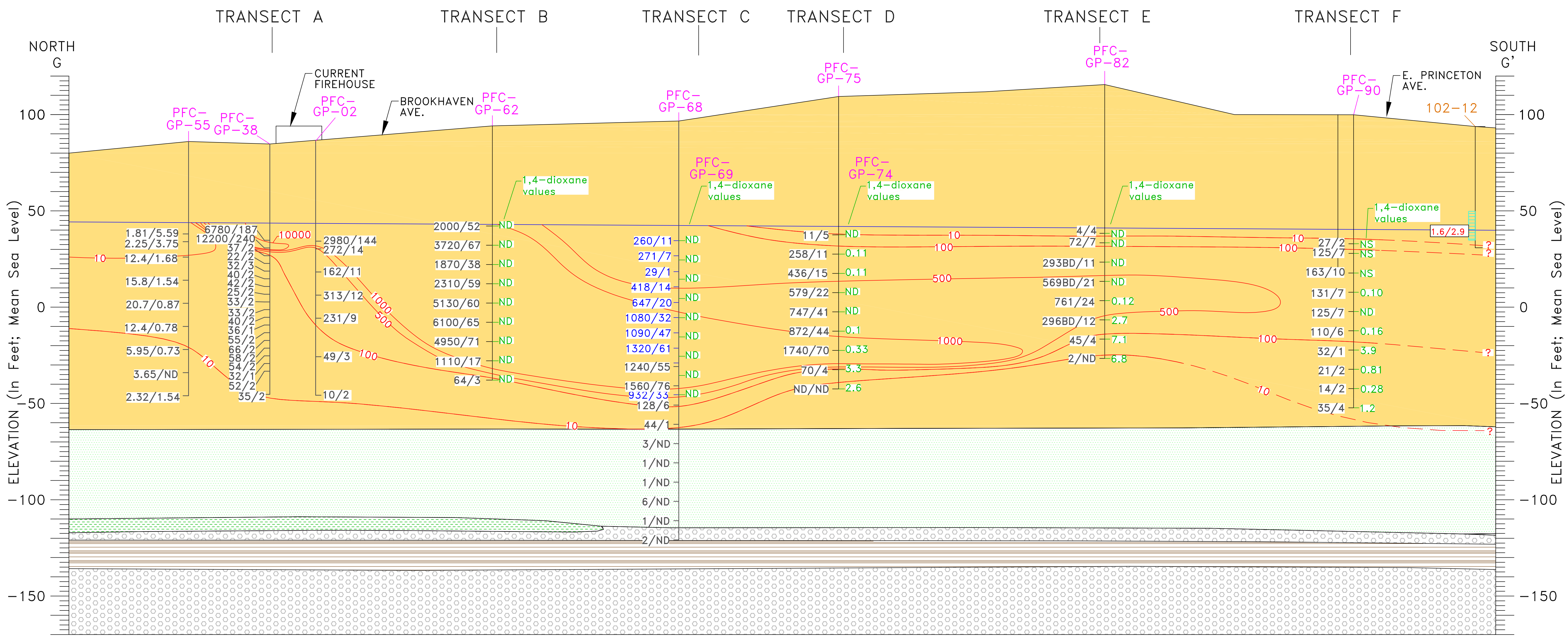
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

CURRENT FIREHOUSE CROSS SECTION F-F' RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 2:1	DATE: 06/24/19	PROJECT NO.: -
CHKD: DEP	APPD: WRD	REV.: 04/30/21	NOTES: -
FIGURE NO.: 9			



LEGEND

Upper Glacial aquifer

- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay

- GL Gardiners Clay
- GS Gardiners Clay – Silt

Magothy aquifer

- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undifferentiated)
- MO Magothy – OTHER

HORIZONTAL SCALE

0 500 FEET

102-12 BNL Well ID

PFC-GP-55 Geoprobe Well ID

NS = Well Not Sampled

ND = Not Detected

ND/1.75 PFOS Value/PFOA Value in (ng/L)

—10— ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 – Jan 10, 2020

Monitoring Well Screen

ng/L– Nanograms Per Liter

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 – JANUARY 26, 2021 SAMPLING EVENTS.

3) DATA FOR GP-02 ARE FROM MAY 2018 AND DATA FOR GP-38 ARE FROM NOVEMBER 2018.

4) CONTOUR INTERVAL IS AS SHOWN.

5) BNL WELL ID COLOR CORRESPONDS TO LONG-TERM MONITORING PROGRAM WELL LOCATION MAP.

Q:\2020\BNLab\20-01 EPD\Task 04 PFAS Characterization\Figures\Phase 5\2021-02-11\Fig_10A CF Section G-G' 021121.dwg

BROOKHAVEN NATIONAL LABORATORY

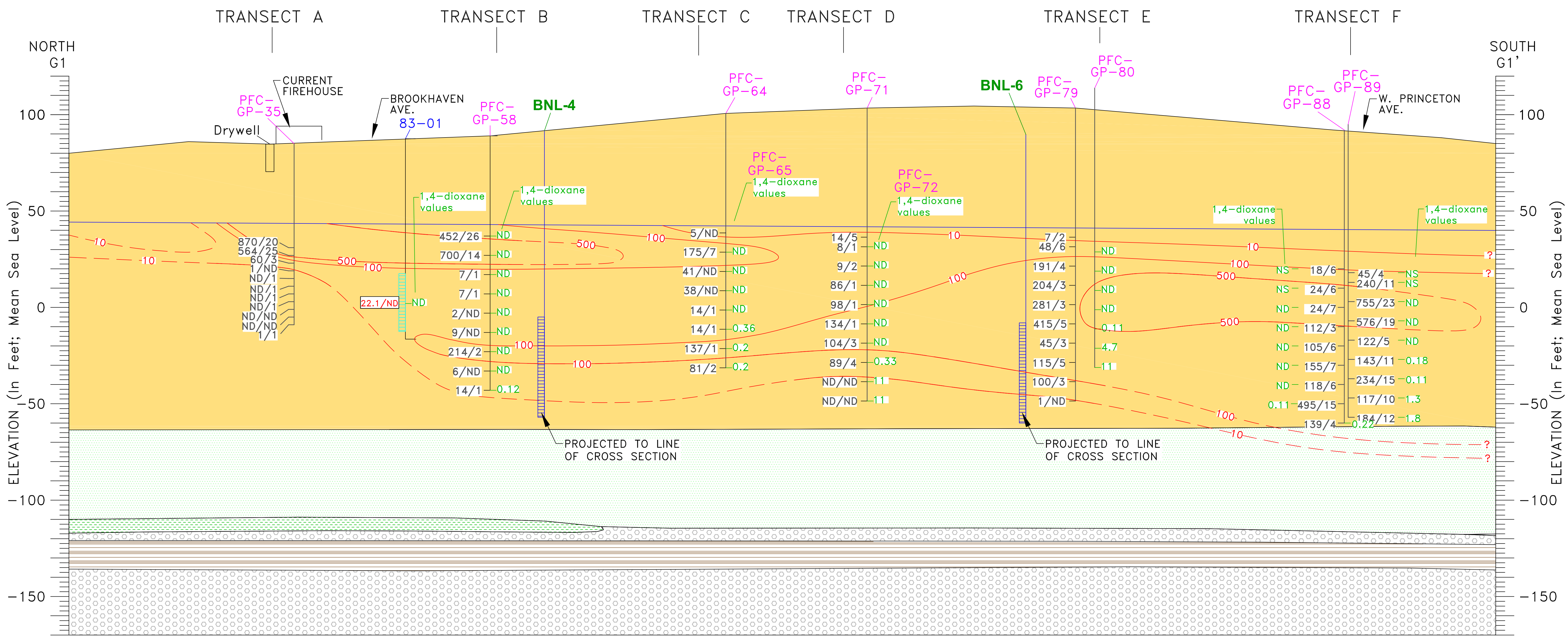
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

CURRENT FIREHOUSE CROSS SECTION G-G'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 20:1	DATE: 08/18/20	PROJECT NO.: –
CHKD: WRD	APPD: WRD	REV.: 02/11/21	NOTES: –
FIGURE NO.: 10A			



LEGEND

Upper Glacial aquifer

- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay

- GL Gardiners Clay
- GS Gardiners Clay – Silt

Magothy aquifer

- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undifferentiated)
- MO Magothy – OTHER

HORIZONTAL SCALE
0 500 FEET

102–12 BNL Well ID

PFC–GP–35 Geoprobe Well ID

NS = Well Not Sampled

ND = Not Detected

ND/1.75 PFOS Value/PFOA Value in (ng/L)

—10— ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 – Jan 10, 2020

Monitoring Well Screen

ng/L– Nanograms Per Liter

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 – JANUARY 26, 2021 SAMPLING EVENTS.

3) CONTOUR INTERVAL IS AS SHOWN.

4) BNL WELL ID COLOR CORRESPONDS TO LONG-TERM MONITORING PROGRAM WELL LOCATION MAP.

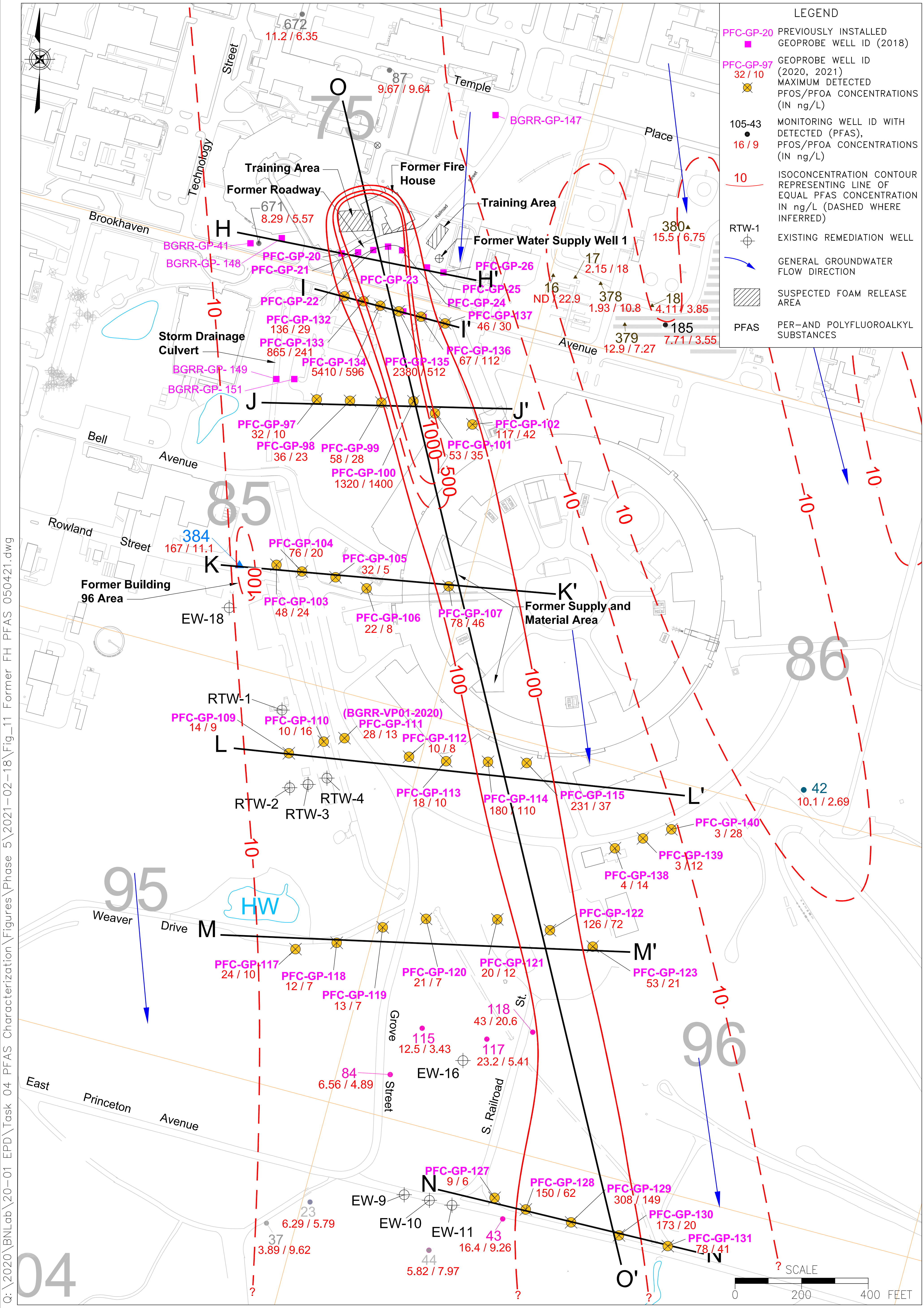
Q:\2020\BNLab\20-01 EPD\Task 04 PFAS Characterization\Figures\Phase 5\2021-02-11\Fig_10B CF Section G1-G1' 021621.dwg

BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:
CURRENT FIREHOUSE CROSS SECTION G1–G1'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 20:1	DATE: 08/18/20	PROJECT NO.: –
CHKD: WRD	APPD: WRD	REV.: 02/16/21	NOTES: –
FIGURE NO.: 10B			



BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

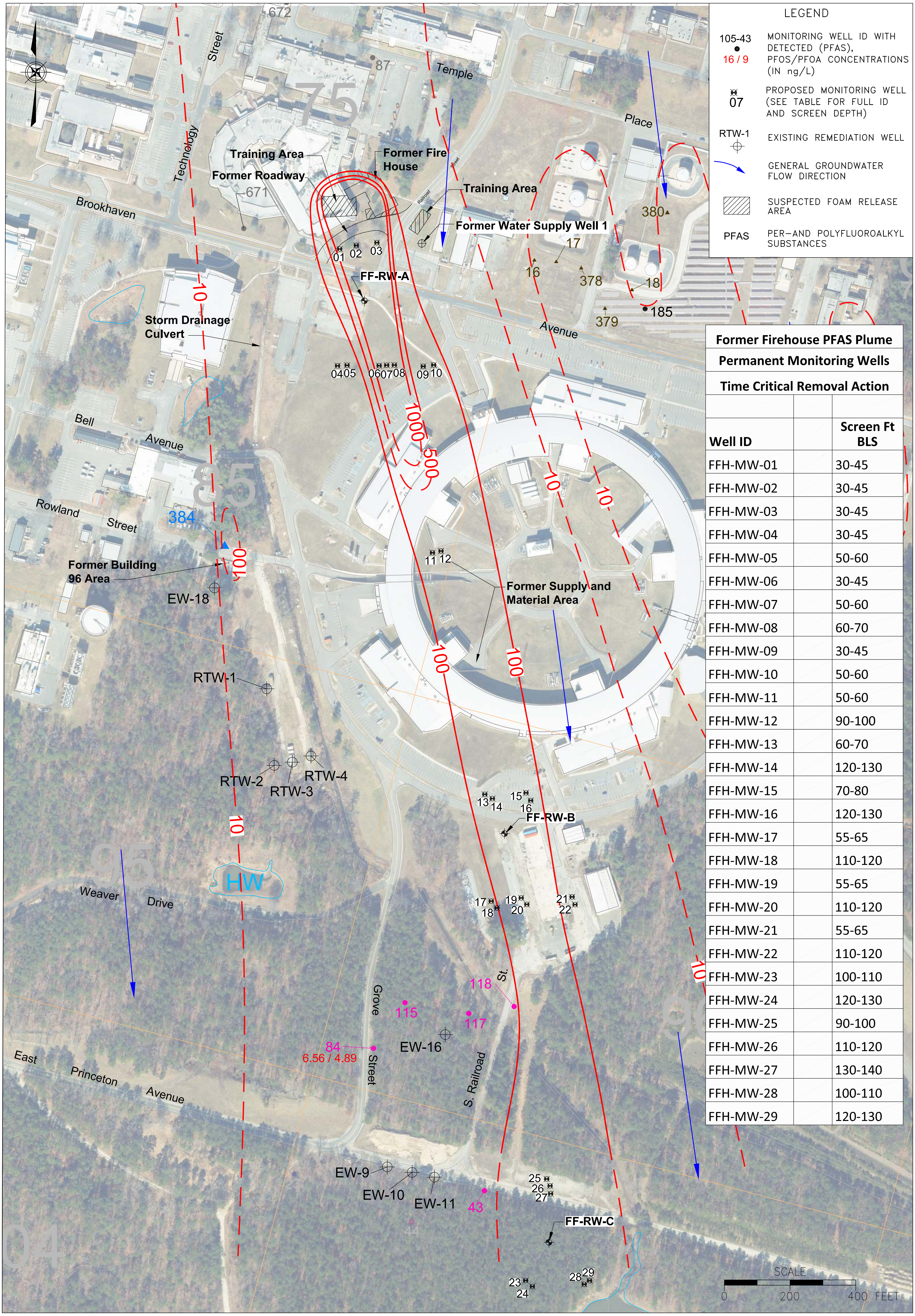
TITLE:

FORMER FIREHOUSE PFAS PLUME

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	—	02/5/20	—
CHKD:	APPD:	REV.:	NOTES:
DEP	DEP	05/04/21	—

FIGURE NO.: 11



Former Firehouse PFAS Plume

Permanent Monitoring Wells

Time Critical Removal Action

Well ID	Screen Ft BLS
FFH-MW-01	30-45
FFH-MW-02	30-45
FFH-MW-03	30-45
FFH-MW-04	30-45
FFH-MW-05	50-60
FFH-MW-06	30-45
FFH-MW-07	50-60
FFH-MW-08	60-70
FFH-MW-09	30-45
FFH-MW-10	50-60
FFH-MW-11	50-60
FFH-MW-12	90-100
FFH-MW-13	60-70
FFH-MW-14	120-130
FFH-MW-15	70-80
FFH-MW-16	120-130
FFH-MW-17	55-65
FFH-MW-18	110-120
FFH-MW-19	55-65
FFH-MW-20	110-120
FFH-MW-21	55-65
FFH-MW-22	110-120
FFH-MW-23	100-110
FFH-MW-24	120-130
FFH-MW-25	90-100
FFH-MW-26	110-120
FFH-MW-27	130-140
FFH-MW-28	100-110
FFH-MW-29	120-130

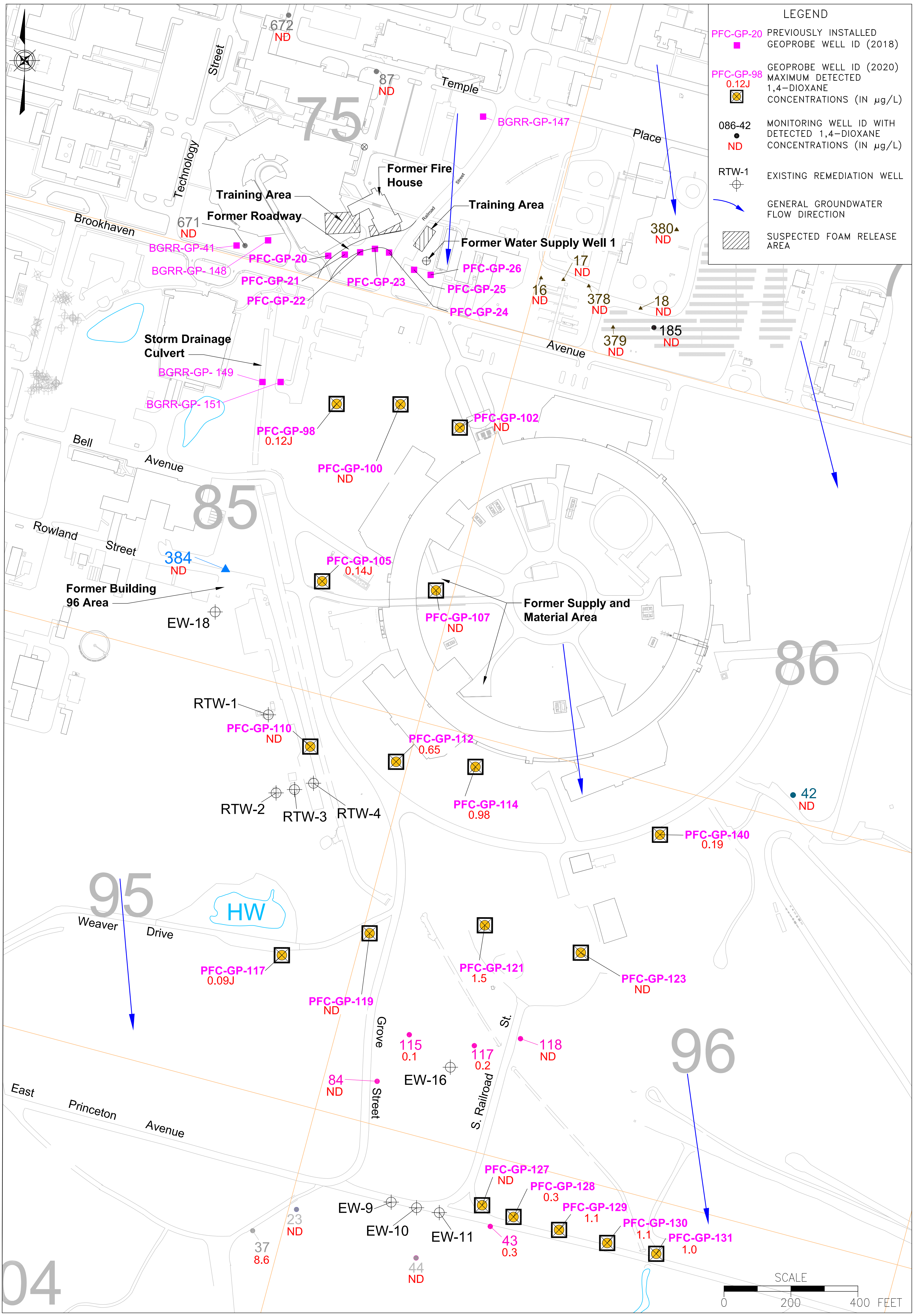
BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE: FORMER FIREHOUSE PROPOSED MONITORING WELL LOCATIONS

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT: HZ.: —	DATE: 02/5/20	PROJECT NO.: —
CHKD: DEP	APPD: DEP	REV.: 05/10/21	NOTES: —
FIGURE NO.: 11a			



Q:\2020\BNLab\20-01 EPD\Task 04 PFAS Characterization\Figures\Phase 5\2021-02-18\Fig_12 Former FH 1,4-dioxane 050421.dwg

BROOKHAVEN NATIONAL LABORATORY

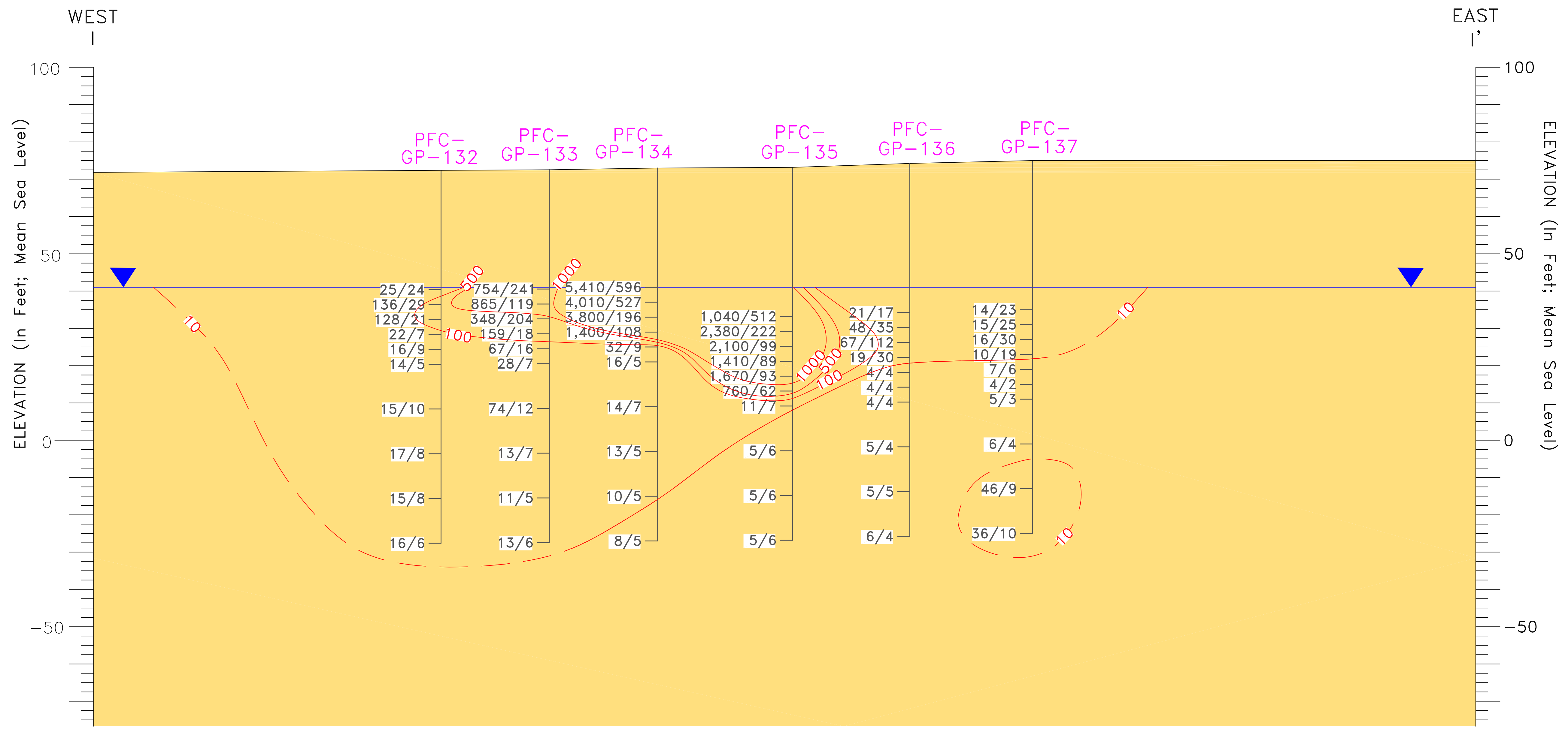
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

FORMER FIREHOUSE 1,4-DIOXANE RESULTS

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT: HZ.: —	DATE: 02/5/20	PROJECT NO.: —
CHKD: DEP	APPD: DEP	REV.: 05/04/21	NOTES: —
FIGURE NO.: 12			



LEGEND

Upper Glacial aquifer

- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay

- GL Gardiners Clay
- GS Gardiners Clay − Silt

Magothy aquifer

- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undiff)
- MO Magothy − OTHER

HORIZONTAL SCALE

0 100 200 FEET

PFC−GP−132 Geoprobe Well ID

40/2 Geoprobe PFOS Value/PFOA Value in ng/L

NS = Well Not Sampled

ND = Not Detected

10 ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 − Jan. 10. 2020

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, MORE DETAILED REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 − JANUARY 26, 2021 SAMPLING EVENTS.

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BROOKHAVEN NATIONAL LABORATORY

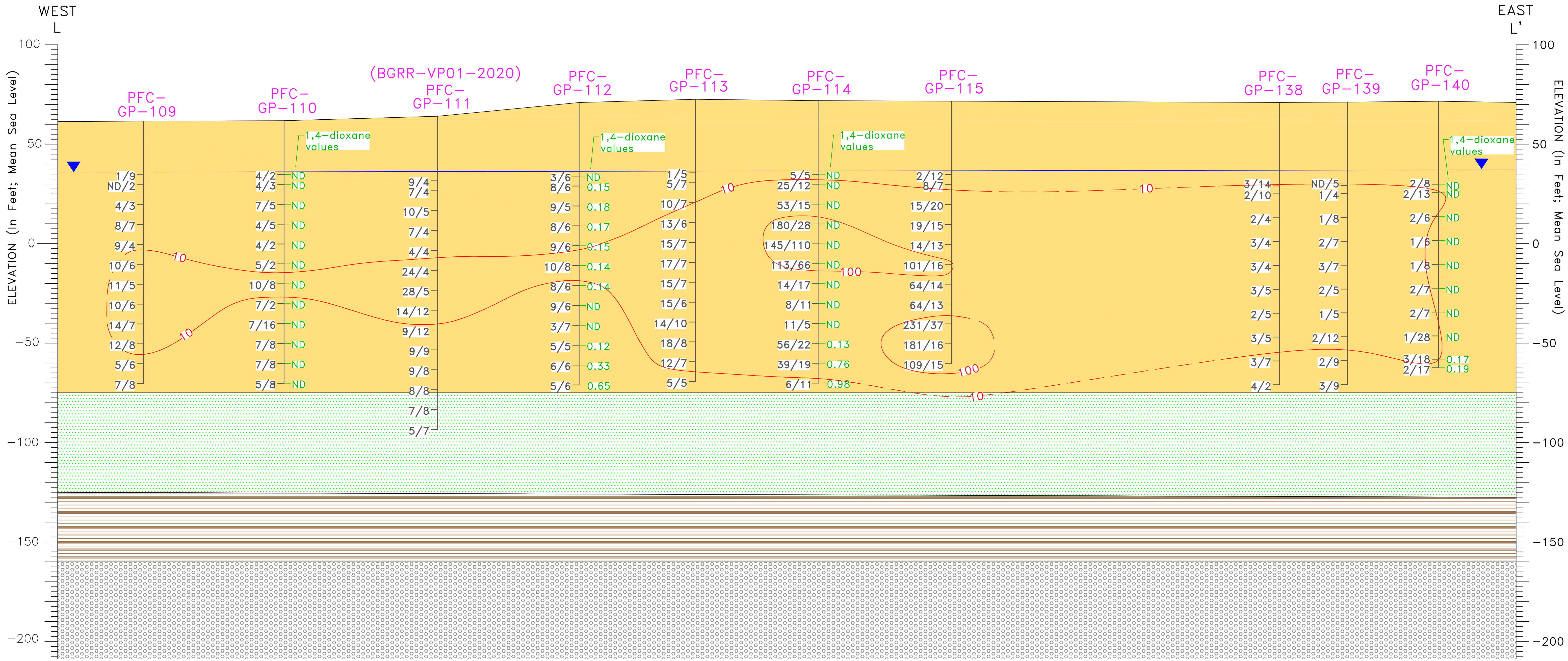
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

FORMER FIREHOUSE CROSS SECTION I−I' RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 2:1	DATE: 06/24/19	PROJECT NO.: −
CHKD: DEP	APPD: WRD	REV.: 05/10/21	NOTES: −
FIGURE NO.: 15			



LEGEND

Upper Glacial aquifer

UG Upper Glacial Sands

UC Upper Glacial Silts & Clays

UU Upton Unit

Gardiners Clay

GL Gardiners Clay

GS Gardiners Clay − Silt

Magothy aquifer

MA Magothy Sands and Clay

MB Magothy Brown Clay

MC Magothy Clays (undiff)

MO Magothy − OTHER

HORIZONTAL SCALE 0 100 200 FEET

PFC−GP−109 Geoprobe Well ID

40/2 Geoprobe PFOS Value/PFOA Value in ng/L

NS = Well Not Sampled

ND = Not Detected

10 ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 − Jan. 10. 2020

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, MORE DETAILED REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 − JANUARY 26, 2021 SAMPLING EVENTS.

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BROOKHAVEN NATIONAL LABORATORY

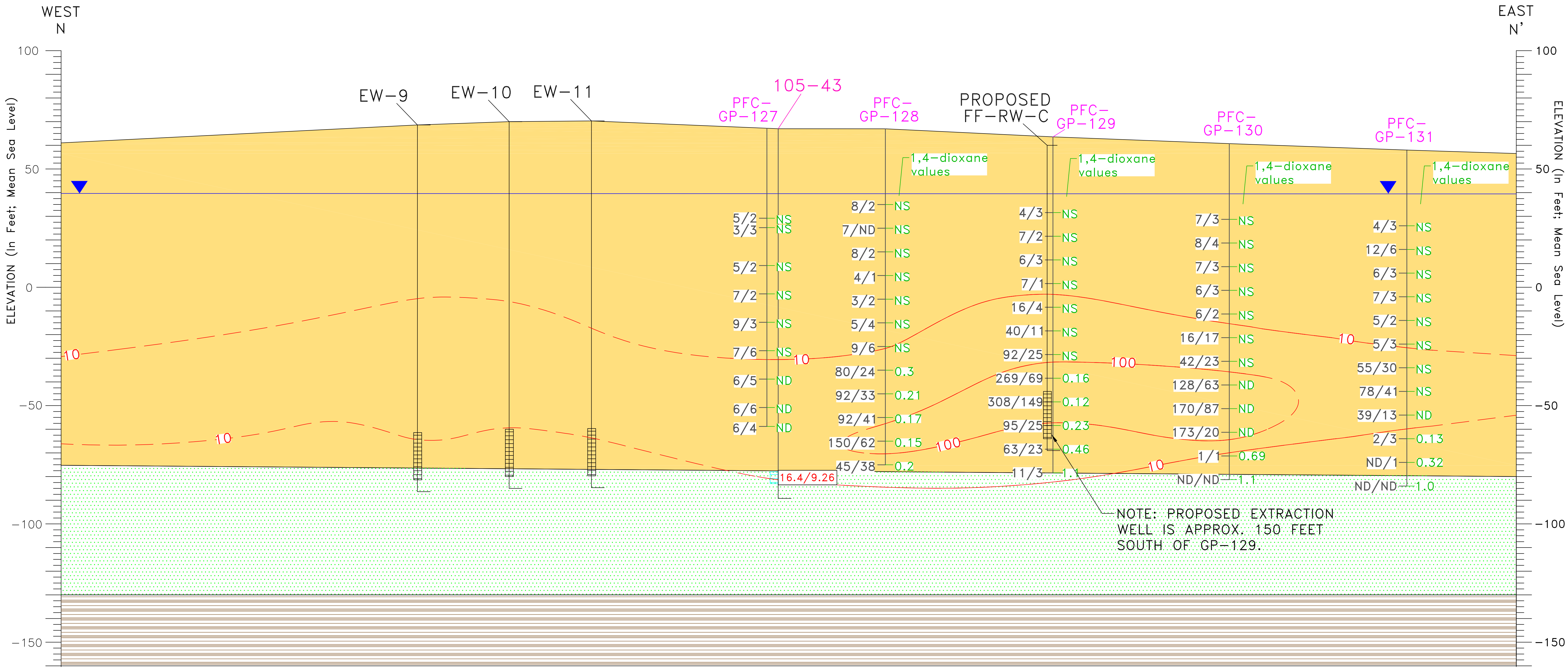
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

FORMER FIREHOUSE CROSS SECTION L−L'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 2:1	DATE: 06/24/19	PROJECT NO.: −
CHKD: DEP	APPD: WRD	REV.: 05/10/21	NOTES: −
FIGURE NO.: 18			



LEGEND

Upper Glacial aquifer
- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay
- GL Gardiners Clay
- GS Gardiners Clay − Silt

Magothy aquifer
- MA Magothy Sands and Clay
- MB Magothy Brown Clay

- MC Magothy Clays (undiff)
- MO Magothy − OTHER

HORIZONTAL SCALE
0 100 200 FEET

- 105−43 BNL Well ID
- PFC−GP−128 Geoprobe Well ID
- 40/2 Geoprobe PFOS Value/PFOA Value in ng/L
- NS = Well Not Sampled
- ND = Not Detected
- 10 ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

- 16.4/9.26 Monitoring Well PFOS Value/PFOA Value in (ng/L)
- Monitoring Well Screen
- Extraction Well Screen
- Water Table As Of Jan. 8 − Jan. 10. 2020

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, MORE DETAILED REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 − JANUARY 26, 2021 SAMPLING EVENTS.

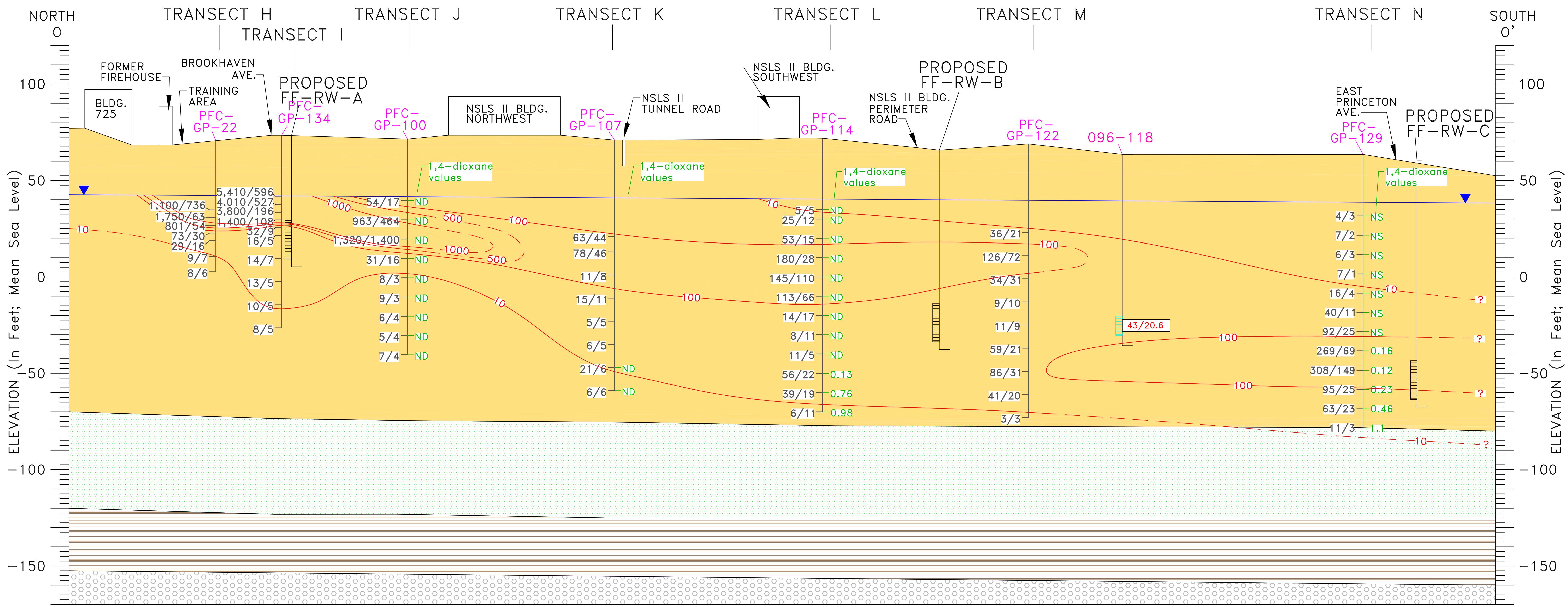
Q:\2020\BNLab\20−01 EPD\Task 04 PFAS Characterization\Figures\Phase 5\2021−02−18\Fig_20 FF Section N−N' 050421.dwg

BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:
FORMER FIREHOUSE CROSS SECTION N−N'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 2:1	DATE: 06/24/19	PROJECT NO.: −
CHKD: DEP	APPD: WRD	REV.: 05/10/21	NOTES: −
FIGURE NO.: 20			



LEGEND

Upper Glacial aquifer

- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay

- GL Gardiners Clay
- GS Gardiners Clay – Silt

Magothy aquifer

- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undifferentiated)
- MO Magothy – OTHER

096-118 BNL Well ID

PFC-GP-22 Geoprobe Well ID

NS = Well Not Sampled

ND = Not Detected

ND/1.75 PFOS Value/PFOA Value in (ng/L)

—10— ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 – Jan 10, 2020

Monitoring Well Screen

ng/L– Nanograms Per Liter

HORIZONTAL SCALE

0 500 FEET

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 – JANUARY 26, 2021 SAMPLING EVENTS.

3) CONTOUR INTERVAL IS AS SHOWN.

4) BNL WELL ID COLOR CORRESPONDS TO LONG-TERM MONITORING PROGRAM WELL LOCATION MAP.

Q:\2020\BNLab\20-01 EPD\Task 04 PFAS Characterization\Figures\Phase 5\2021-02-18\Fig_21 FF Section O-O' 050521.dwg

BROOKHAVEN NATIONAL LABORATORY

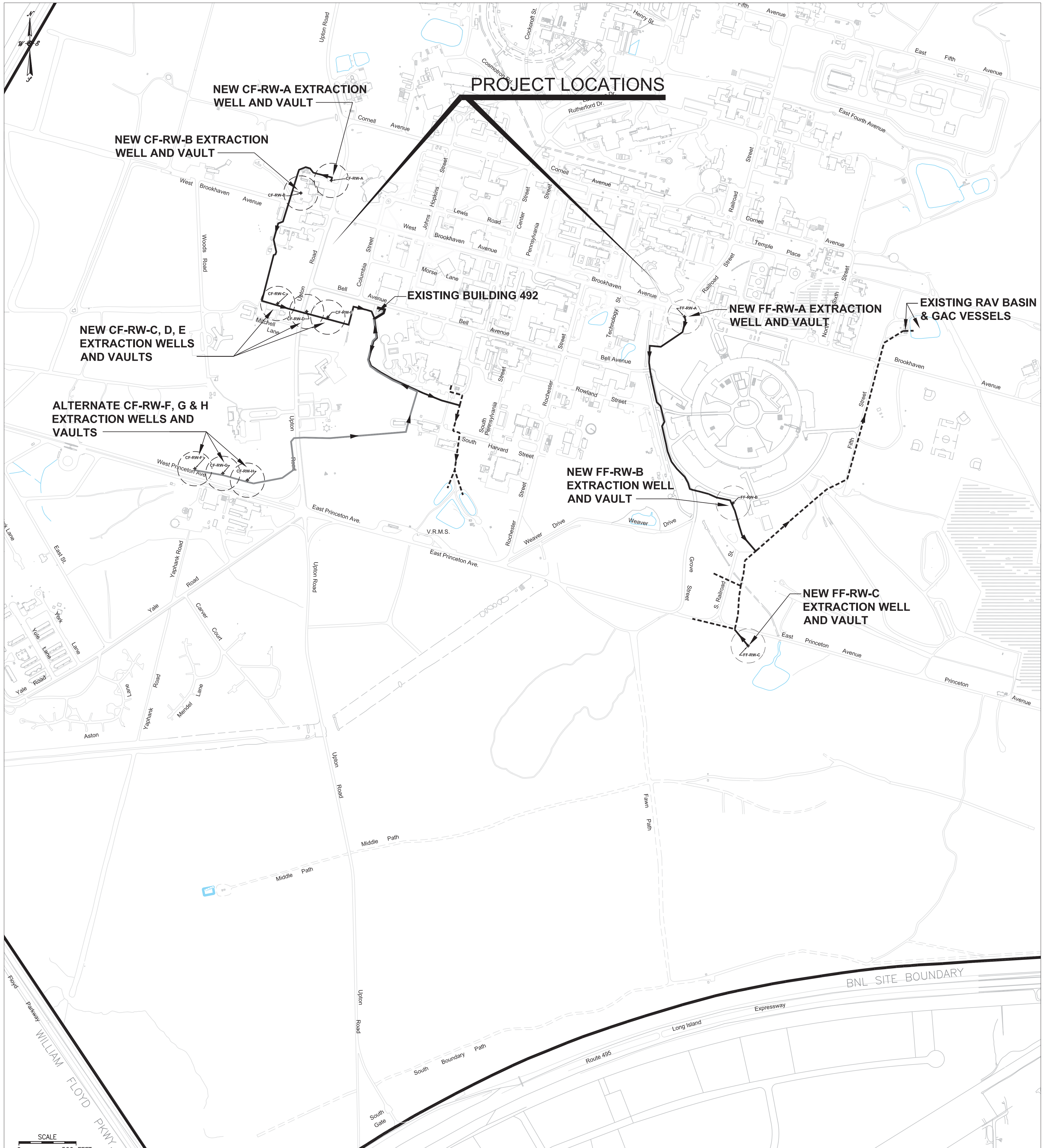
ENVIRONMENTAL PROTECTION DIVISION

TITLE:

FORMER FIREHOUSE CROSS SECTION O–O'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 20:1	DATE: 01/30/21	PROJECT NO.: –
CHKD: WRD	APPD: WRD	REV.: 05/05/21	NOTES: –
FIGURE NO.: 21			



LOCATION MAP
SCALE: 1" = 500'

PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT

Current Firehouse and Former Firehouse areas

100% Design Submittal

DRAWING LIST

SHEET	DRAWING	TITLE
1	T-1	TITLE SHEET, LOCATION PLAN & DRAWING INDEX
2	SP-1	CURRENT & FORMER FIREHOUSE PFAS PLUME DISTRIBUTIONS
3	S-1CF	CURRENT FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 1 OF 5
4	S-2CF	CURRENT FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 2 OF 5
5	S-3CF	CURRENT FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 3 OF 5
6	S-4CF	CURRENT FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 4 OF 5
7	S-5CF	CURRENT FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 5 OF 5
8	E-1CF	CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 1 OF 5
9	E-2CF	CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 2 OF 5
10	E-3CF	CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 3 OF 5
11	E-4CF	CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 4 OF 5
12	E-5CF	CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 5 OF 5
13	M-1CF	CURRENT FIREHOUSE MECHANICAL DETAILS - 1 OF 3
14	M-2CF	CURRENT FIREHOUSE MECHANICAL DETAILS - 2 OF 3
15	M-3CF	CURRENT FIREHOUSE MECHANICAL DETAILS - 3 OF 3
16	S-1FF	FORMER FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 1 OF 4
17	S-2FF	FORMER FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 2 OF 4
18	S-3FF	FORMER FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 3 OF 4
19	S-4FF	FORMER FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 4 OF 4
20	S-5FF	FORMER FIREHOUSE SITE PLAN DETAILS AT RAV BASIN
21	A-1FF	FORMER FIREHOUSE-NEW GAC BUILDING SECTION & DETAILS
22	A-2FF	FORMER FIREHOUSE-NEW GAC BUILDING ELEVATIONS
23	E-1FF	FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 1 OF 5
24	E-2FF	FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 2 OF 5
25	E-3FF	FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 3 OF 5
26	E-4FF	FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 4 OF 5
27	E-5FF	FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS - 5 OF 5
28	E-6	ELECTRICAL DETAILS - 1 OF 1
29	M-4	MECHANICAL DETAILS - 1 OF 2
30	M-5	MECHANICAL DETAILS - 2 OF 2
31	W-1	EXTRACTION AND MONITORING WELL DETAILS
32	CC-1	COMMUNICATIONS AND CONTROLS - 1 OF 2
33	CC-2	COMMUNICATIONS AND CONTROLS - 2 OF 2

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

BROOKHAVEN NATIONAL LABORATORY

UNDER CONTRACT WITH UNITED STATES DEPARTMENT OF ENERGY
ENVIRONMENTAL MANAGEMENT DIRECTORATE & ENVIRONMENTAL PROTECTION DIVISION
UPTON, NEW YORK 11973

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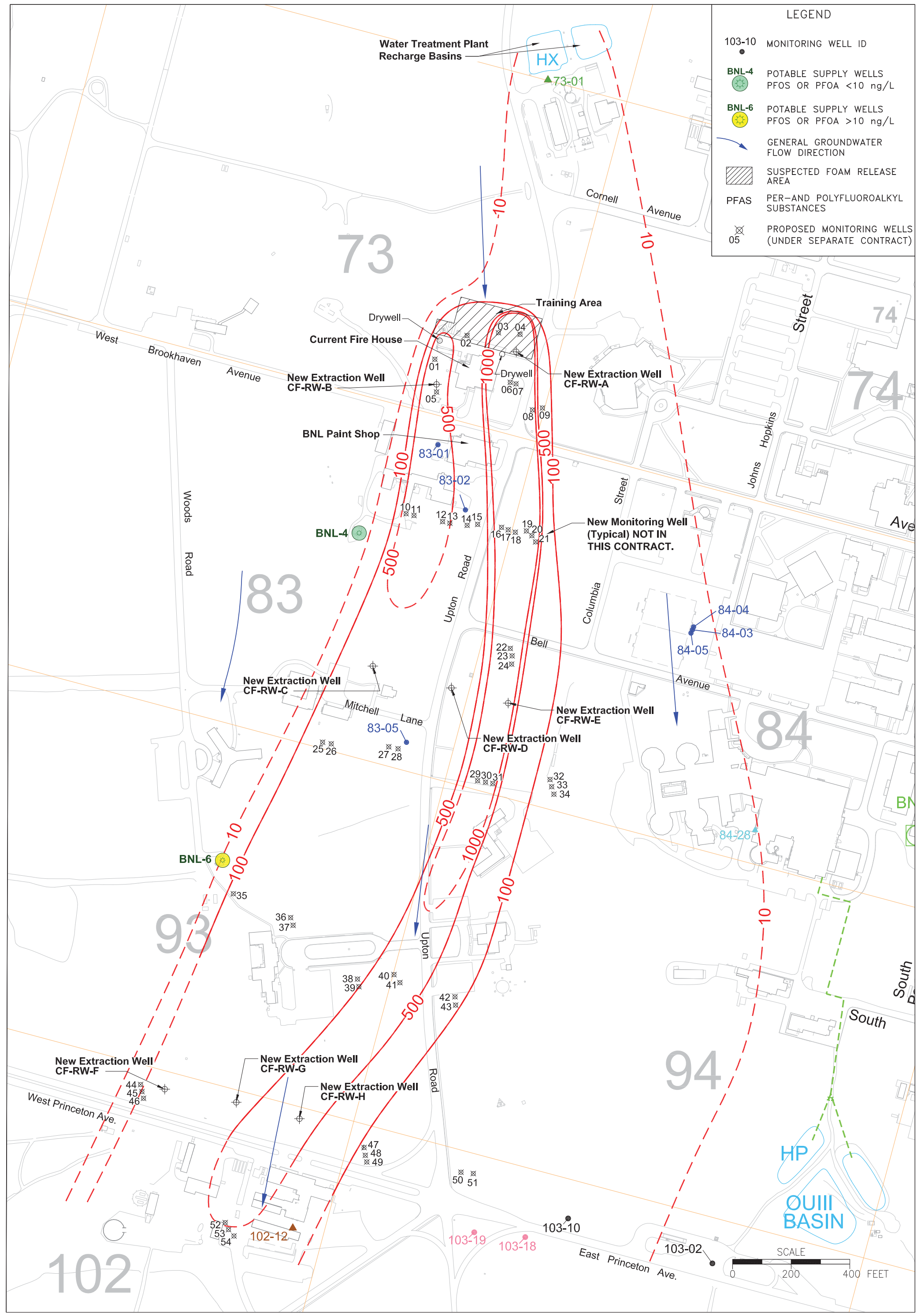
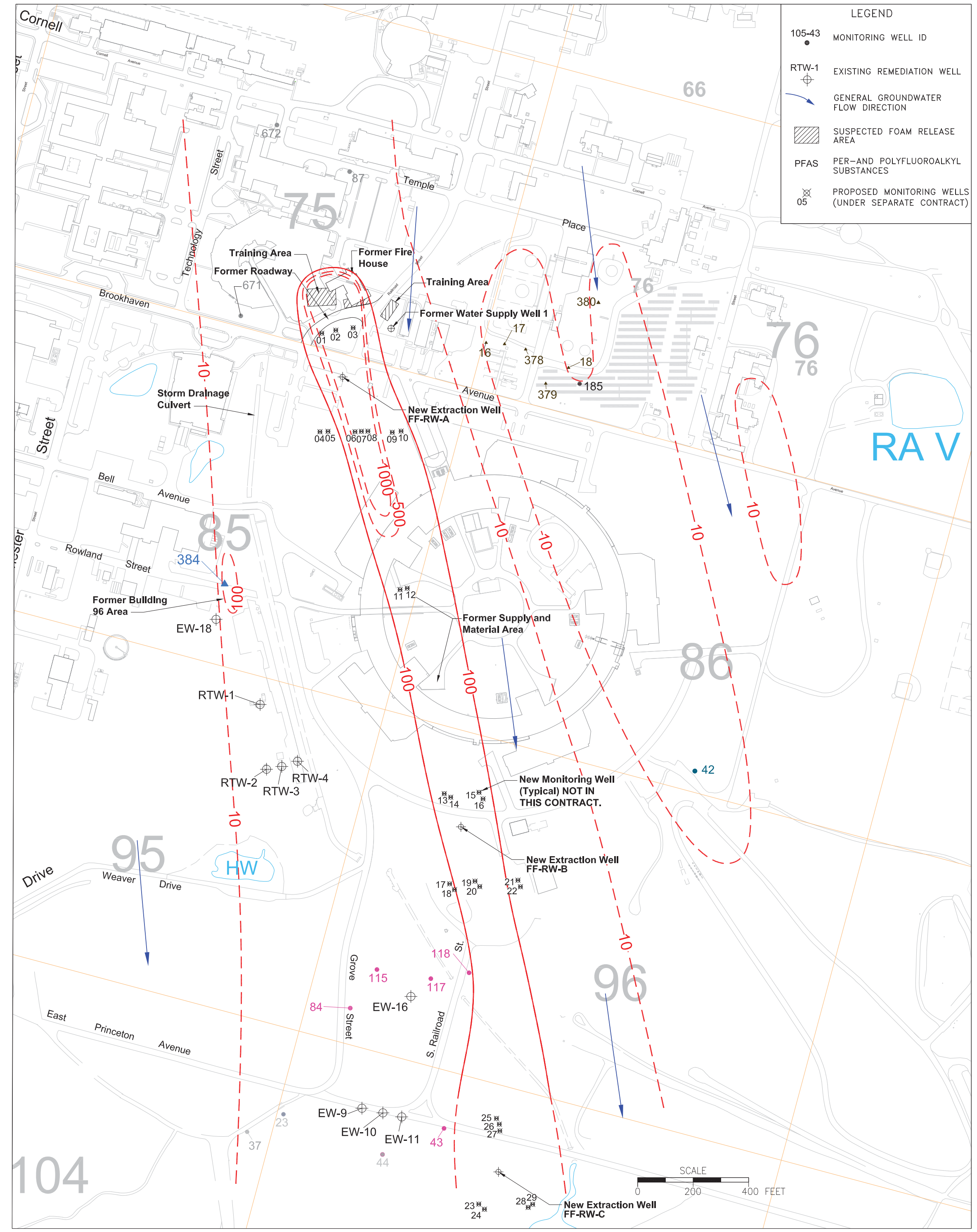
The Third Generation of Excellence in Water Supply, Water Resources, Civil and Environmental Engineering
3555 Veterans Memorial Highway, Suite A, Ronkonkoma NY 11779
PHONE: (631) 234-2220 FAX: (631) 234-2221 E-MAIL: info@jrholzmacher.com

ALTERATION OF THIS DOCUMENT EXCEPT BY A LICENSED PROFESSIONAL IS ILLEGAL

JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: TITLE SHEET, LOCATION PLAN & DRAWING INDEX	
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 1 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: T-1
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			



CURRENT FIREHOUSE AREA
PFAS CHARACTERIZATION



FORMER FIREHOUSE AREA
PFAS CHARACTERIZATION

Current Firehouse New Extraction Wells

Extraction Well Designation	CF-RW-A	CF-RW-B	CF-RW-C	CF-RW-D	CF-RW-E
Approx. Grade Elevation at Well Head (msl)	84	84	100	100	100
Well Diameter (inches)	8	8	8	8	8
Distance to Bottom of Screen (ft msl)	16	10	-37	10	-52
Distance to Bottom of Screen (ft bgs)	68	74	137	90	152
Length of Screen (feet)	20	20	20	20	20
Screen Slot Size (inch/1000)	20	20	20	20	20

Extraction Well Designation	CF-RW-F	CF-RW-G	CF-RW-H
Approx. Grade Elevation at Well Head (msl)	91	93	98
Well Diameter (inches)	8	8	8
Distance to Bottom of Screen (ft msl)	-50	-15	-20
Distance to Bottom of Screen (ft bgs)	141	108	118
Length of Screen (feet)	30	20	20
Screen Slot Size (inch/1000)	20	20	20

Former Firehouse New Extraction Wells

Extraction Well Designation	FF-RW-A	FF-RW-B	FF-RW-C
Approx. Grade Elevation at Well Head (msl)	73	70	60
Well Diameter (inches)	8	8	8
Distance to Bottom of Screen (ft msl)	9	-33	-64
Distance to Bottom of Screen (ft bgs)	64	103	124
Length of Screen (feet)	20	20	20
Screen Slot Size (inch/1000)	20	20	20

NEW MONITORING WELL
WORK TO BE DONE UNDER SEPARATE CONTRACT

Current Firehouse New Monitoring Wells

Monitoring Well Designation	CF MW-01-2021	CF MW-02-2021	CF MW-03-2021	CF MW-04-2021
Approx. Grade Elevation at Well Head (msl)				
Well Diameter (inches)	4"	4"	4"	4"
Distance to Bottom of Screen (ft bgs)				
Length of Screen (feet)	10	10	10	10
Screen Slot Size (inch/1000)	20	20	20	20

Monitoring Well Designation	CF MW-05-2021	CF MW-06-2021	CF MW-07-2021	CF MW-08-2021
Approx. Grade Elevation at Well Head (msl)				
Well Diameter (inches)	4"	4"	4"	4"
Distance to Bottom of Screen (ft bgs)				
Length of Screen (feet)	10	10	10	10
Screen Slot Size (inch/1000)	20	20	20	20

NEW MONITORING WELL
WORK TO BE DONE UNDER SEPARATE CONTRACT

Former Firehouse New Monitoring Wells

Monitoring Well Designation	FF MW-01-2021	FF MW-02-2021	FF MW-03-2021	FF MW-04-2021
Approx. Grade Elevation at Well Head (msl)				
Well Diameter (inches)	4"	4"	4"	4"
Distance to Bottom of Screen (ft bgs)				
Length of Screen (feet)	10	10	10	10
Screen Slot Size (inch/1000)	20	20	20	20

Monitoring Well Designation	FF MW-05-2021	FF MW-06-2021	FF MW-07-2021	FF MW-08-2021
Approx. Grade Elevation at Well Head (msl)				
Well Diameter (inches)	4"	4"	4"	4"
Distance to Bottom of Screen (ft bgs)				
Length of Screen (feet)	10	10	10	10
Screen Slot Size (inch/1000)	20	20	20	20

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA
		1					

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NATIONAL LABORATORY

UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
ENVIRONMENTAL MANAGEMENT DIRECTORATE &
ENVIRONMENTAL PROTECTION DIVISION
UPTON, NEW YORK 11973

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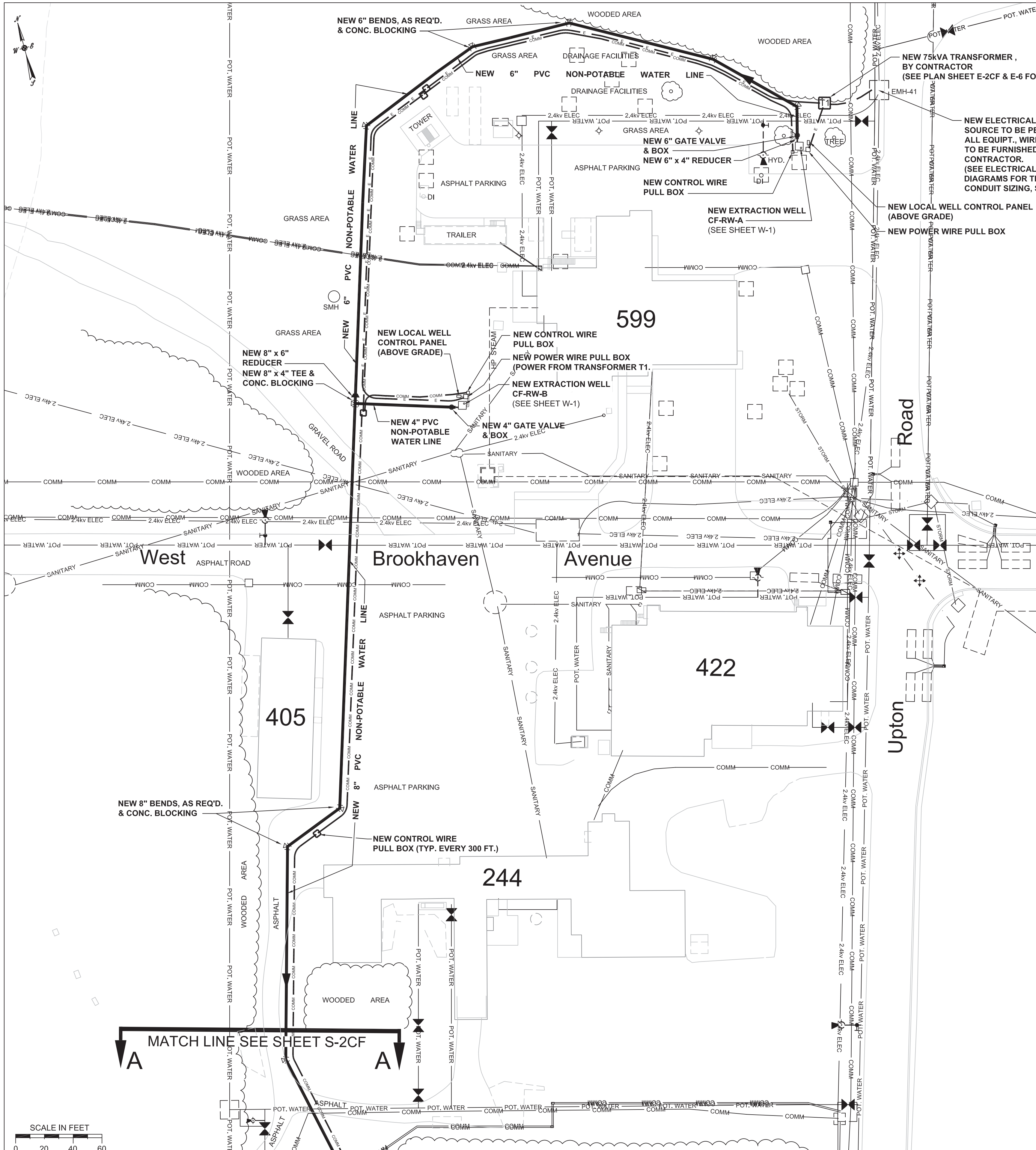
J.R. HOLZMACHER P.E., LLC
The Third Generation of Excellence In
Water Supply, Water Resources, Civil and Environmental Engineering
3555 Veterans Memorial Highway, Suite A, Ronkonkoma NY 11779
PHONE: (631) 234-2220 FAX: (631) 234-2221 E-MAIL: info@holzmacher.com

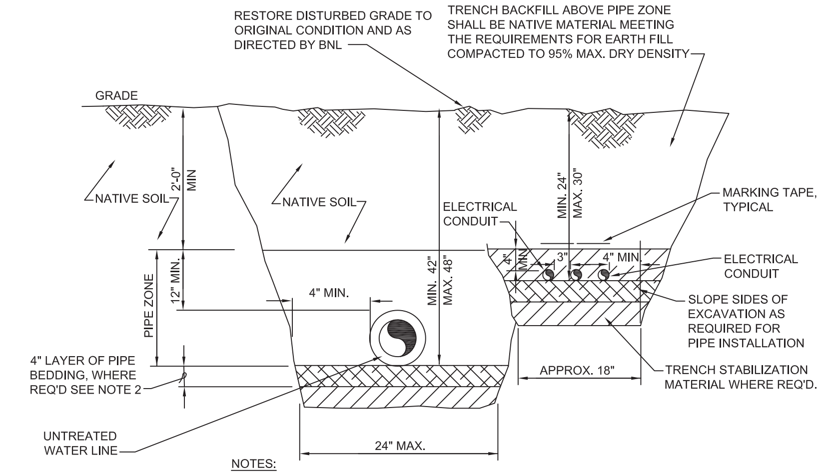
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: CURRENT & FORMER FIREHOUSE PFAS PLUME DISTRIBUTIONS	
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 2 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: SP-1
PROJ. QA: A3-MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			



CURRENT FIREHOUSE SITE PLAN - 1 OF 5

SCALE: 1" = 40'

NOTE: CONTRACTOR TO HAND DIG TO VERIFY THE PRESENCE OR ABSENCE OF ACTIVE OR ABANDONED UNDERGROUND UTILITIES



NOTES:

1. PROVIDE 12" MINIMUM SEPARATION BETWEEN ELECTRICAL CONDUITS AND WATER PIPES.
2. IF FIELD ENGINEER CONCURS THAT EXISTING SUBGRADE MEETS REQUIREMENTS FOR PIPE BEDDING, TRENCH BACKFILL, NO EXCAVATION BELOW PIPE ZONE IS REQUIRED, PREPARATION OF TRENCH BOTTOM/ BEDDING MATERIAL SHALL CONFORM TO ANSI/ASTM D1557 STANDARDS.
3. CONTRACTOR TO DESIGNATE A COMPETENT PERSON FOR ALL TRENCHING AND EXCAVATION OPERATIONS,THIS PERSON MUST HAVE AUTHORITY TO TAKE PROMPT CORRECTIVE ACTION TO CORRECT WORK PLACE HAZARDS.

TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA
		1					

BROOKHAVEN NATIONAL LABORATORY

UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
ENVIRONMENTAL MANAGEMENT DIRECTORATE & ENVIRONMENTAL PROTECTION DIVISION
UPTON, NEW YORK 11973

STATE OF NEW YORK · JAMES R. HOLZMACHER · No. 66054 · LICENSED PROFESSIONAL ENGINEER

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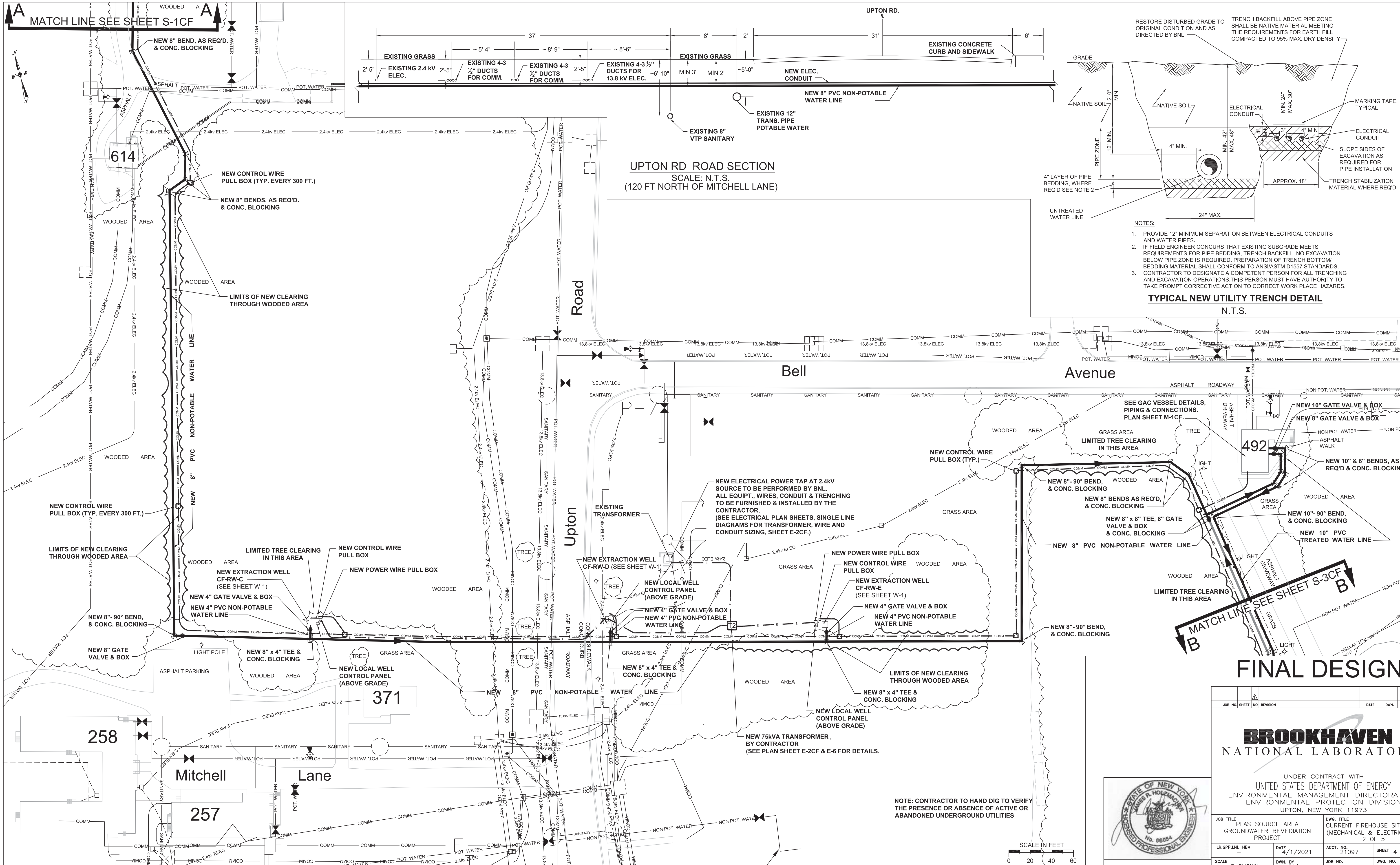
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: CURRENT FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) – 1 OF 5	
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 3 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: S–1CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			



TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.

NOTES:

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CURRENT FIREHOUSE SITE PLAN - 2 OF 5

SCALE: 1" = 40'

FINAL DESIGN

JOB NO.	SHEET	NO.	REVISION	DATE	DWN.	APP'D.	QA

BROOKHAVEN
NATIONAL LABORATORY

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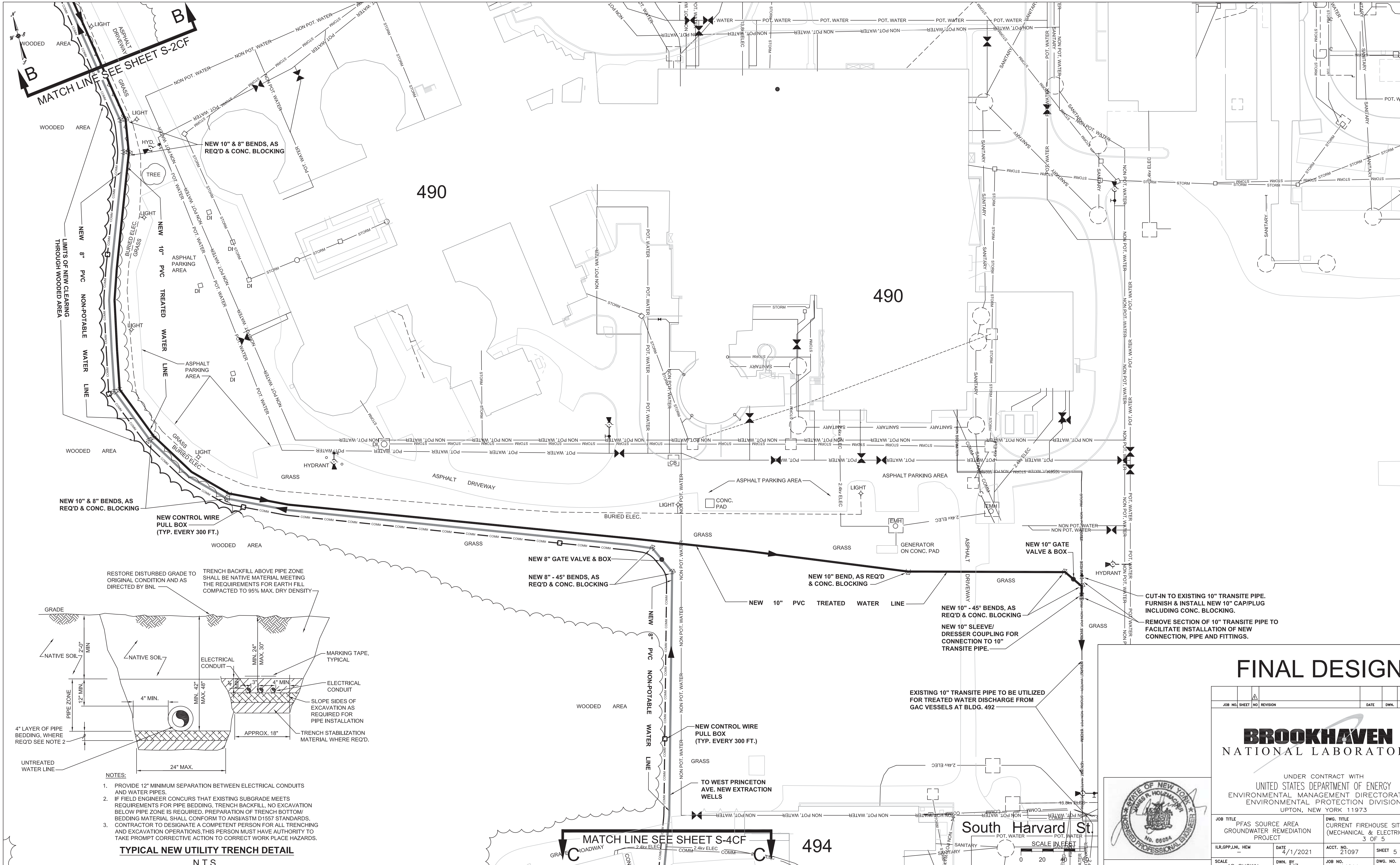
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021
ACCT. NO.: 21097	SHEET 4 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ
JOB NO.: 14011	DWG. NO.: S-2CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH
BLDG. NO.: –	
PATH: –	



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TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.

CURRENT FIREHOUSE SITE PLAN - 3 OF 5

SCALE: 1" = 40'

NOTE: CONTRACTOR TO HAND DIG TO VERIFY THE PRESENCE OR ABSENCE OF ACTIVE OR ABANDONED UNDERGROUND UTILITIES

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA
		1					

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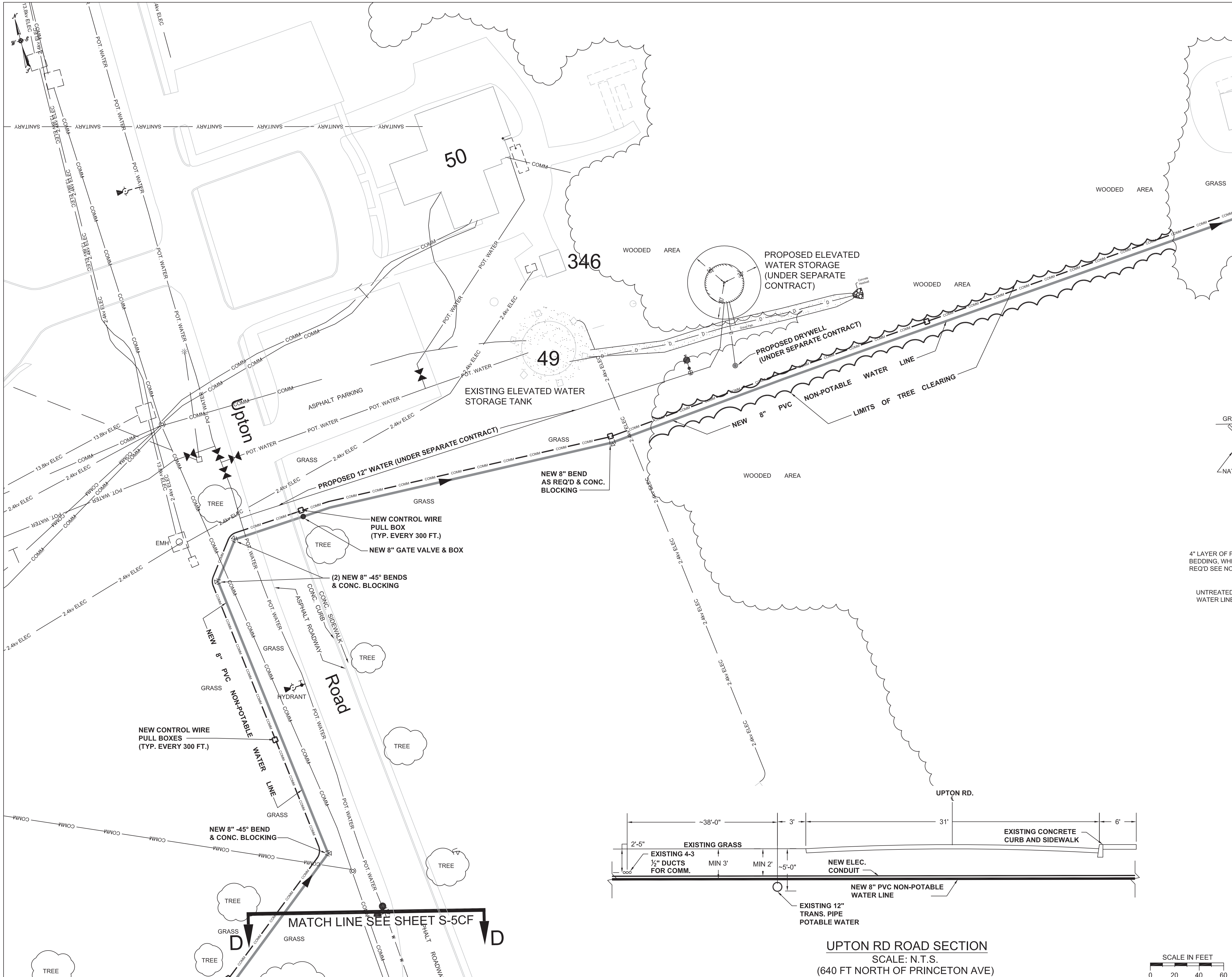
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 5 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: S–3CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			

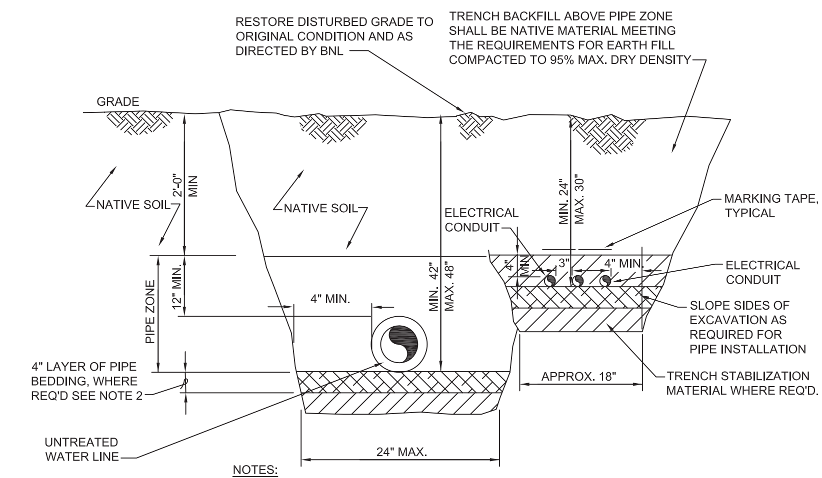


CURRENT FIREHOUSE SITE PLAN - 4 OF 5

SCALE: 1" = 40'

SCALE IN FEET

0 20 40 60



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TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.

UPTON RD ROAD SECTION

SCALE: N.T.S.

(640 FT NORTH OF PRINCETON AVE)

NOTE: CONTRACTOR TO HAND DIG TO VERIFY THE PRESENCE OR ABSENCE OF ACTIVE OR ABANDONED UNDERGROUND UTILITIES

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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J.R. HOLZMACHER P.E., LLC

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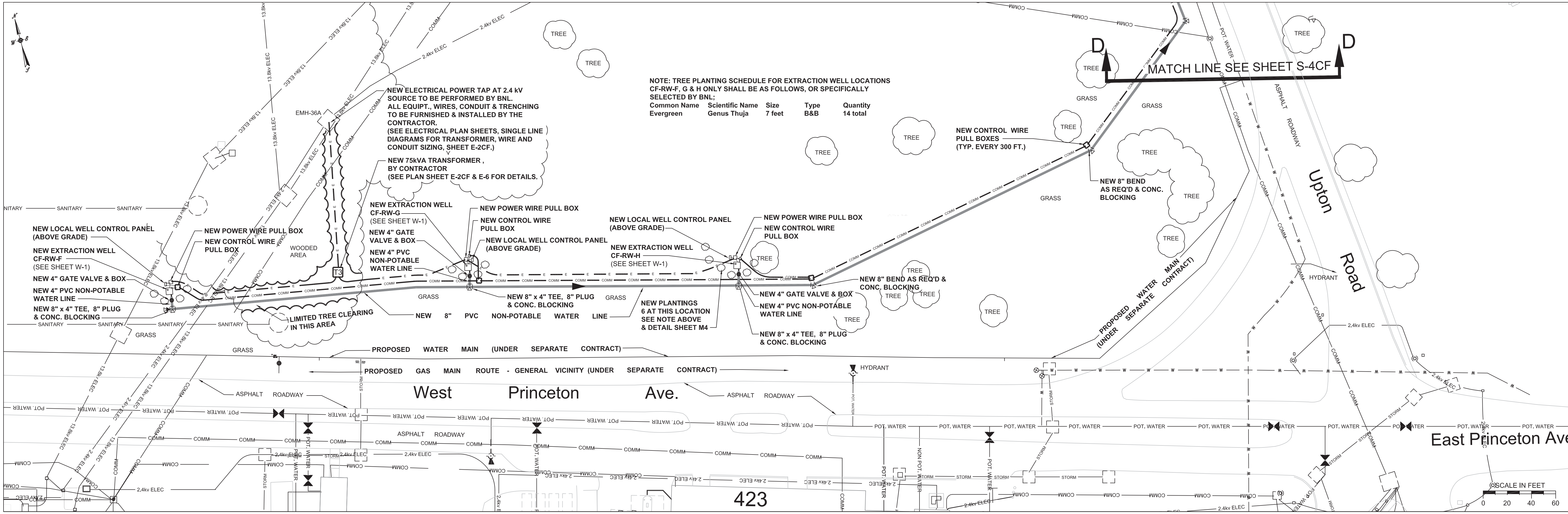
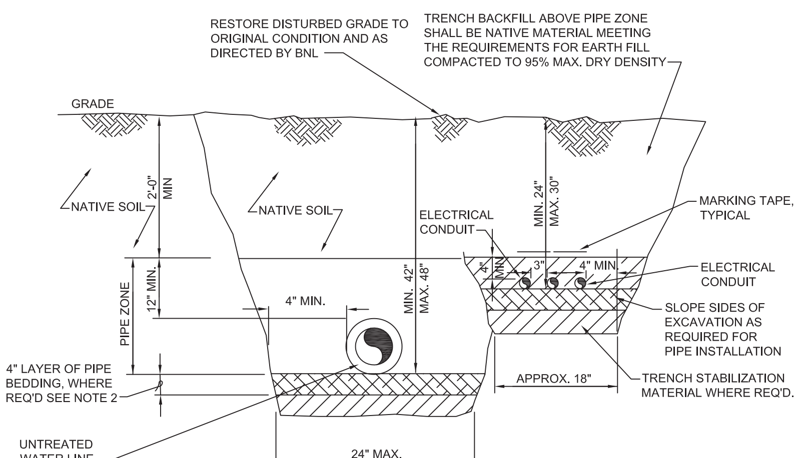
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 6 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: S-4CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.	
PATH: –			



CURRENT FIREHOUSE SITE PLAN - 5 OF 5

SCALE: 1" = 40'

NOTE: CONTRACTOR TO HAND DIG TO VERIFY THE PRESENCE OR ABSENCE OF ACTIVE OR ABANDONED UNDERGROUND UTILITIES



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TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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UPTON, NEW YORK 11973

STATE OF NEW YORK — JAMES R. HOLZMACHER — No. 66054 — LICENSED PROFESSIONAL ENGINEER

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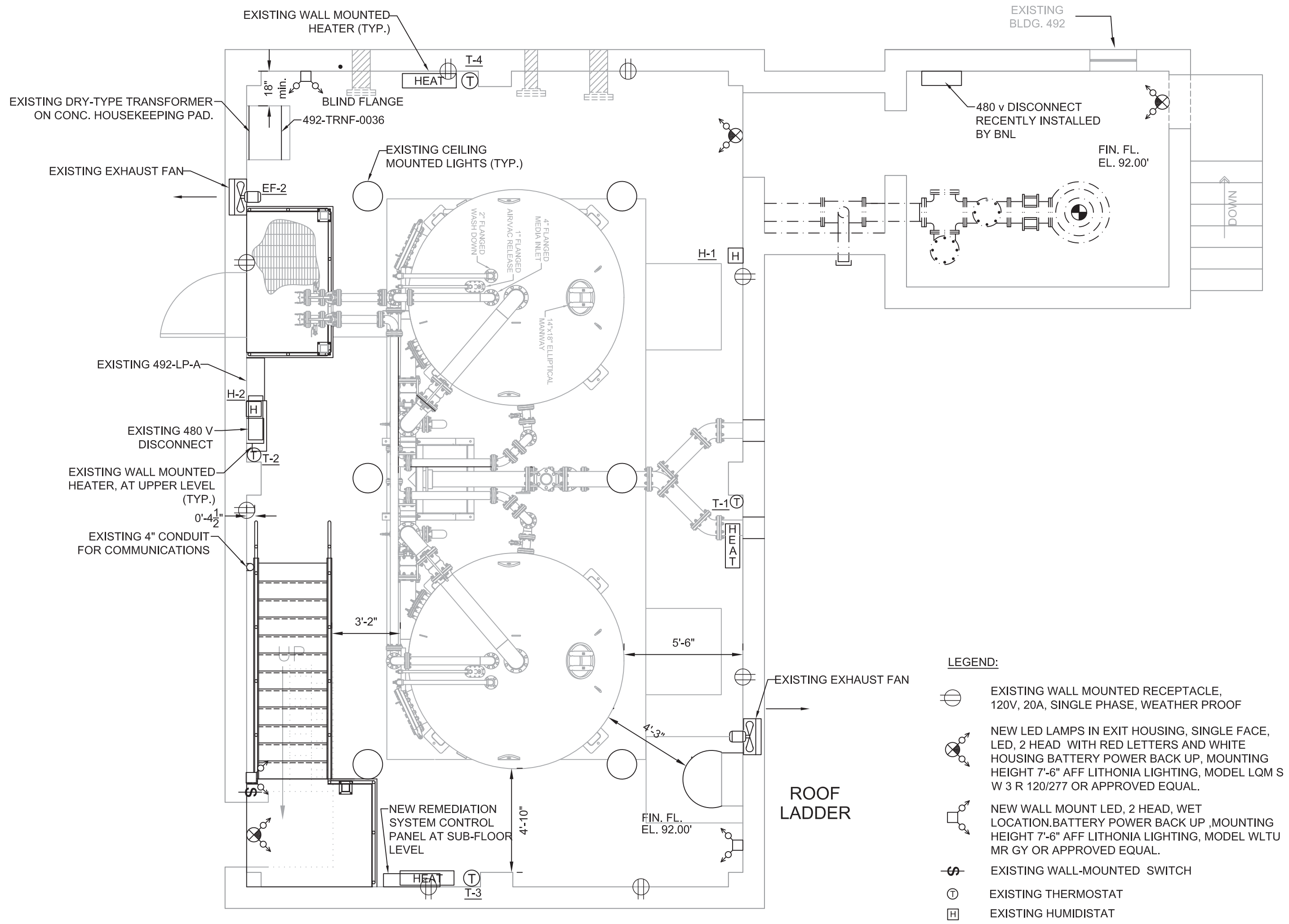
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021
ACCT. NO.: 21097	SHEET 7 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ
JOB NO.: 14011	DWG. NO.: S-5CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH
BLDG. NO.: –	PATH: –



LEGEND:

- EXISTING WALL MOUNTED RECEPTACLE, 120V, 20A, SINGLE PHASE, WEATHER PROOF
- NEW LED LAMPS IN EXIT HOUSING, SINGLE FACE, LED, 2 HEAD WITH RED LETTERS AND WHITE HOUSING BATTERY POWER BACK UP, MOUNTING HEIGHT 7'-6" AFF LITHONIA LIGHTING, MODEL LQM S W 3 R 120/277 OR APPROVED EQUAL.
- NEW WALL MOUNT LED, 2 HEAD, WET LOCATION,BATTERY POWER BACK UP ,MOUNTING HEIGHT 7'-6" AFF LITHONIA LIGHTING, MODEL WLTU MR GY OR APPROVED EQUAL.
- EXISTING WALL-MOUNTED SWITCH
- EXISTING THERMOSTAT
- EXISTING HUMIDISTAT
- HEAT EXISTING HEATER
- EXISTING INTERIOR LIGHTS

BUILDING 492 FLOOR PLAN

SCALE 1/4"=1'-0"

PANELBOARD NO: ***492 LP-A***

SECTION: 1 OF 1
MOUNTING: SURFACE
LOCATION: BLDG

VOLTAGE: 208Y/120
PHASE: 3
WIRE: 4
NEUTRAL: 100%

BUS: 225 A
MAIN: MCB
INTERRUPTING RATING: 10 KAIC
ELECTRONIC GRADE PANEL: NO
SUBMETER: YES

CKT NO.	DESCRIPTION	LOAD (KVA) LTS	REC	EQPT	MECH	ELEV	MISC	CIRCUIT BREAKER AMPS	POLES		CIRCUIT BREAKER AMPS	POLES	LOAD (KVA) LTS	REC	EQPT	MECH	ELEV	MISC	DESCRIPTION	CKT NO
1	LIGHTING (Interior & Exterior)	1.0						20	1	A	20	1		0.7					RECEPTACLE	2
3	**PANEL VIEW**			**0.3**				20	1	B	20	1		0.7					RECEPTACLE	4
5	SPARE							20	1	C	20	1							SPARE	6
7	2kW UNIT HEATER 1				1.0			20		A	20	1				0.5			EXHAUST FANS (2)	8
9	"				1.0				2	B	20					1.0			2kW UNIT HEATER 3	10
11	2kW UNIT HEATER 2				1.0			20		C		2				1.0			"	12
13	"				1.0				2	A	20					1.0			2kW UNIT HEATER 4	14
15	Pressure Sw. Alarm Relay				0.1			20	1	B		2				1.0			"	16
17	EMERGENCY/EXIT LIGHTS	0.2						20	1	C	20	1							SPARE	18
19	SPARE							20	1	A	20	1							SPARE	20
21	SPARE							20	1	B	20	1							SPARE	22
23	SPARE							20	1	C	20	1							SPARE	24
25	SPACE							-	1	A	-	1							SPACE	26
27	SPACE							-	1	B	-	1							SPACE	28
29	SPACE							-	1	C	-	1							SPACE	30
31	SPACE							-	1	A	-	1							SPACE	32
33	SPACE							-	1	B	-	1							SPACE	34
35	SPACE							-	1	C	-	1							SPACE	36
37	SPACE							-	1	A	-	1							SPACE	38
39	SPACE							-	1	B	-	1							SPACE	40
41	SPACE							-	1	C	-	1							SPACE	42

PHASE BALANCE

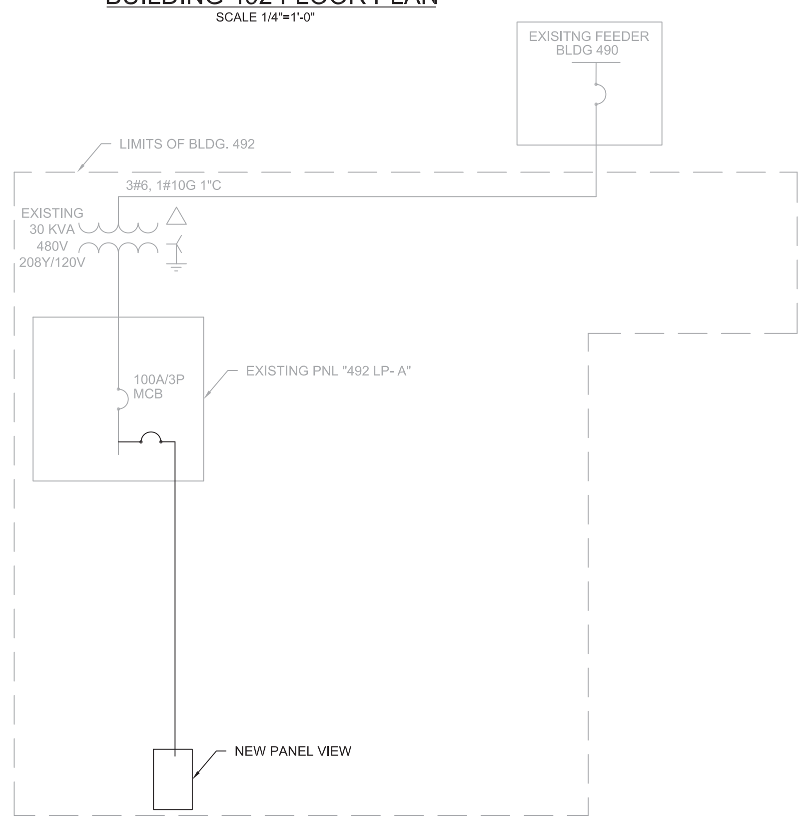
	LTS	REC	EQPT	MECH	ELEV	MISC	TOTAL	% DIF
PHASE A CONNECTED KVA	1.0	0.7	0.0	3.5	0.0	0.0	5.2	34.9
PHASE B CONNECTED KVA	0.0	0.7	0.3	3.1	0.0	0.0	4.1	7.4
PHASE C CONNECTED KVA	0.2	0.0	0.0	2.0	0.0	0.0	2.2	-42.4
AVERAGE PHASE CONNECTED KVA							3.8	

LOAD SUMMARY

LTS	REC	EQPT	MECH	ELEV	MISC	SUBTOT	SPARE	TOTAL	
1	1	0	9	0	0	11	25		CONNECTED KVA
									25% OF THE LARGEST MOTOR
	NOTE 1	NOTE 2		NOTE 3	NOTE 4				DEMAND FACTOR
1.25	1.00	1.00	1.00	1.00	1.00				CONTINUOUS / NON-CONTINUOUS
1	1	0	9	0	0	12	3	15	DESIGN KVA
NOTE 1 - PER NEC 220.44 (100% OF1ST 10 + 50% OF REMAINING)								208	PHASE VOLTAGE
NOTE 2 -								41	DESIGN AMPS
NOTE 3 - PER NEC 620.14									
NOTE 4 -									

NOTE: NEW CIRCUITS IN BOLD

PANEL SCHEDULE - "PANEL A"



SINGLE LINE DIAGRAM - BUILDING 492

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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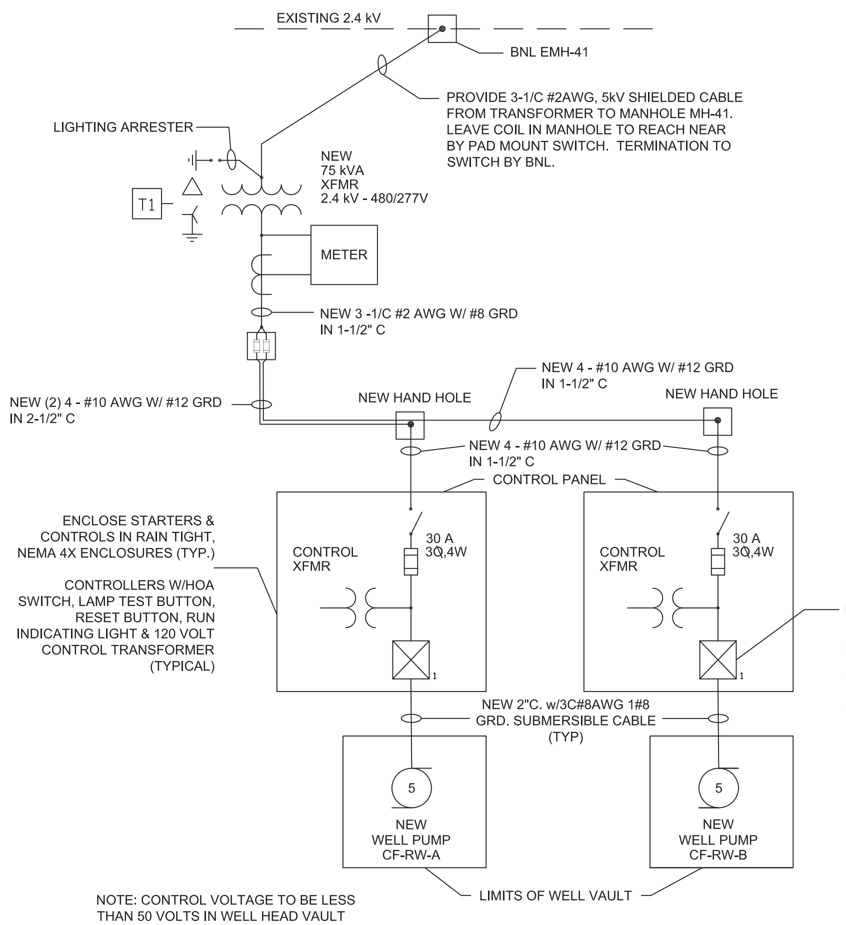
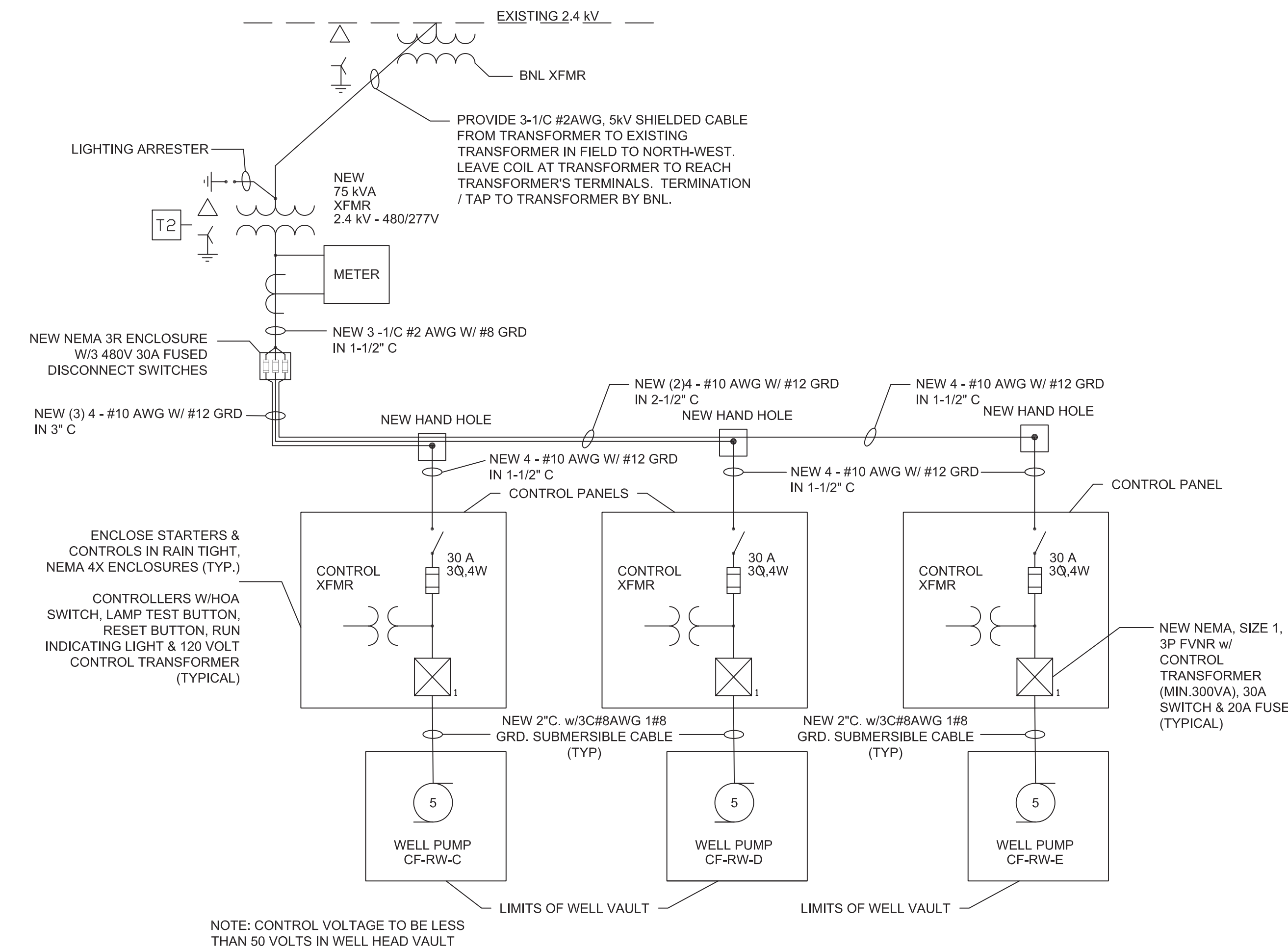
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS – 1 OF 5	
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 8 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: E-1CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: 492	
PATH: –			



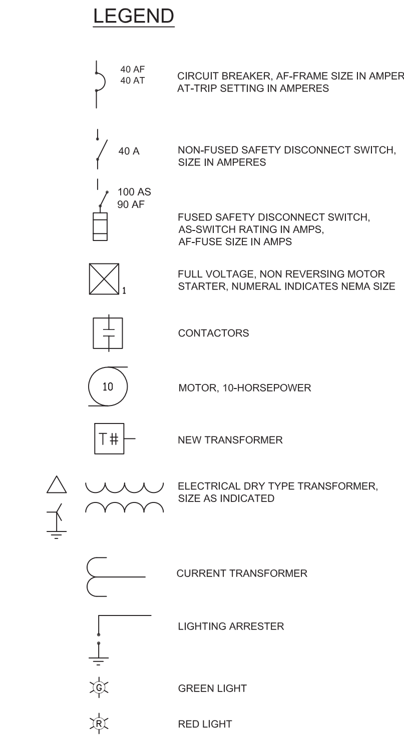
SINGLE LINE POWER DIAGRAM - CFH 1

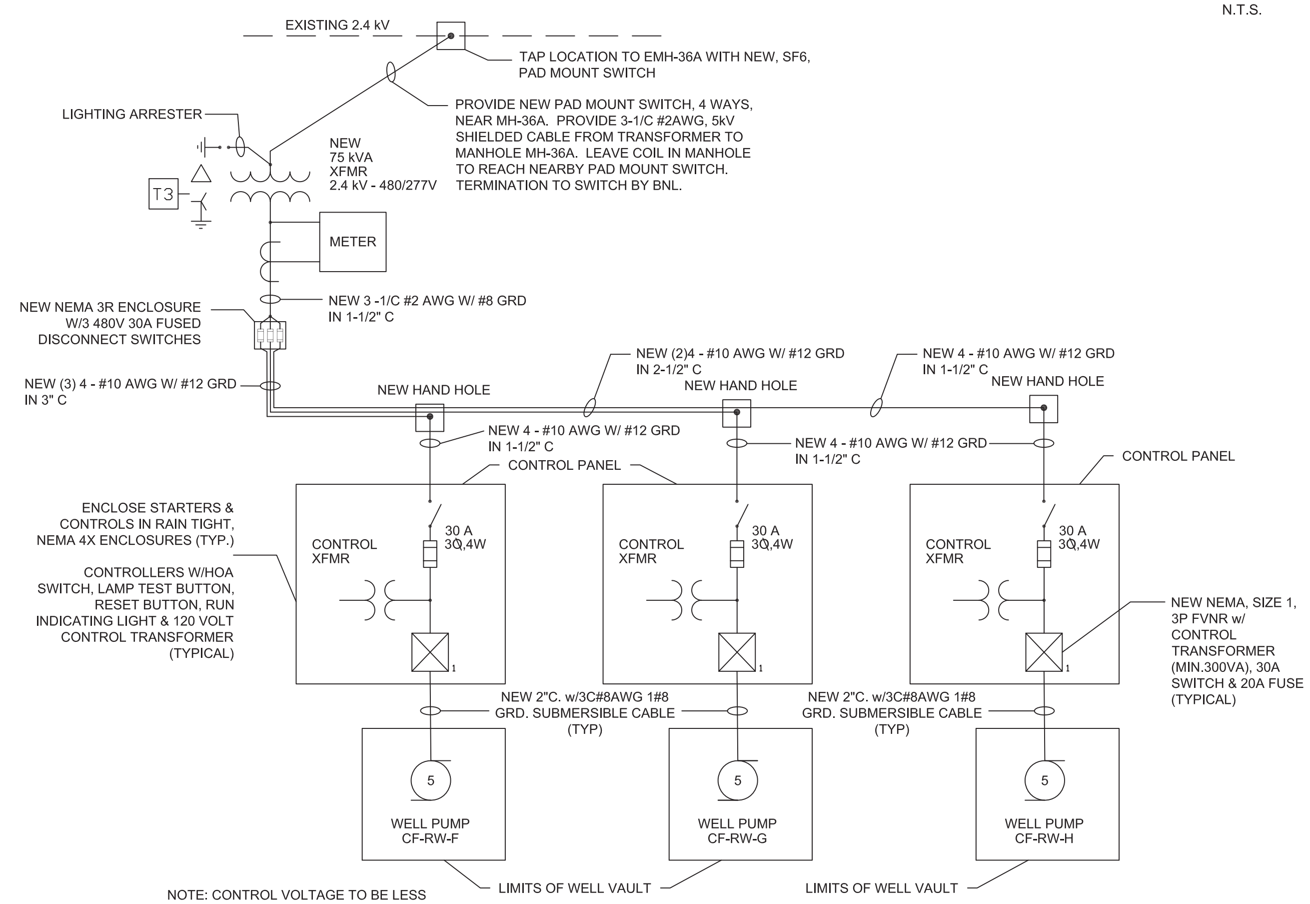
N.T.S.



SINGLE LINE POWER DIAGRAM - CFH 2

N.T.S.





SINGLE LINE POWER DIAGRAM - CFH 3

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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JOB TITLE PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS – 2 OF 5	
ILR,GPP,LNI, HEM –	DATE 4/1/2021	ACCT. NO. 21097	SHEET 9 OF 33
SCALE AS SHOWN	DWN. BY AJZ	JOB NO. 14011	DWG. NO. E–2CF
PROJ. QA A3–MINOR	APP'D. BY JRH	BLDG. NO.	
PATH: –			

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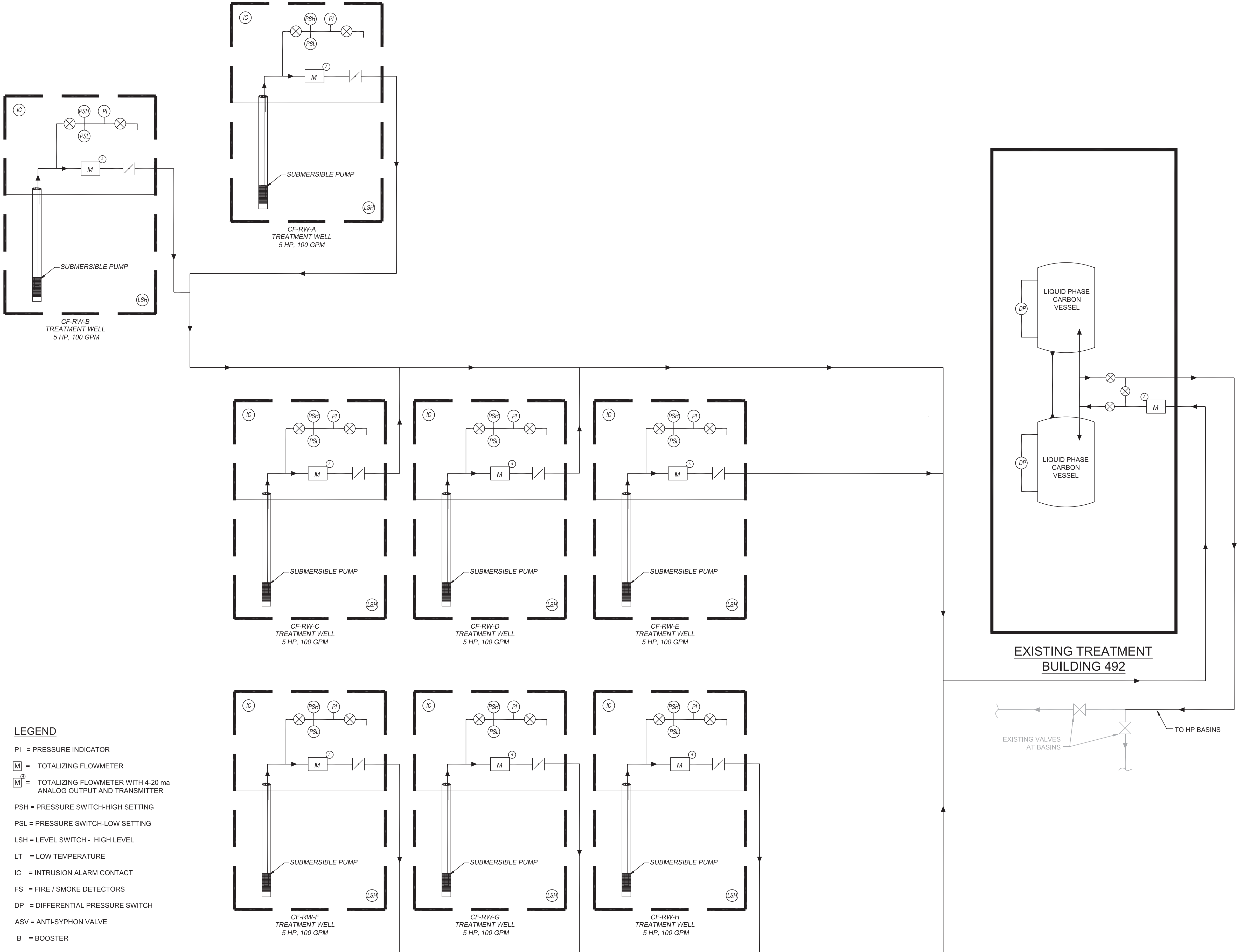

LEGEND

PI = PRESSURE INDICATOR

M = TOTALIZING FLOWMETER

M = TOTALIZING FLOWMETER WITH 4-20 ma ANALOG OUTPUT AND TRANSMITTER

PSH = PRESSURE SWITCH-HIGH SETTING

PSL = PRESSURE SWITCH-LOW SETTING

LSH = LEVEL SWITCH - HIGH LEVEL

LT = LOW TEMPERATURE

IC = INTRUSION ALARM CONTACT

FS = FIRE / SMOKE DETECTORS

DP = DIFFERENTIAL PRESSURE SWITCH

ASV = ANTI-SYPHON VALVE

B = BOOSTER

= SAMPLE PORT

PROCESS AND INSTRUMENTATION DIAGRAM - CFH

N.T.S.

NOTE: SEE PLAN SHEETS 31-CC-1 AND 32-CC-2 FOR COMMUNICATION AND CONTROLS DETAILS

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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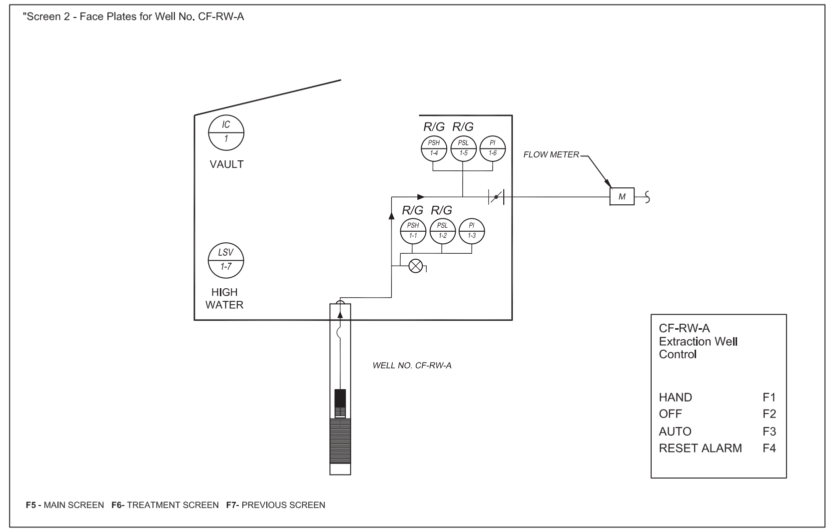
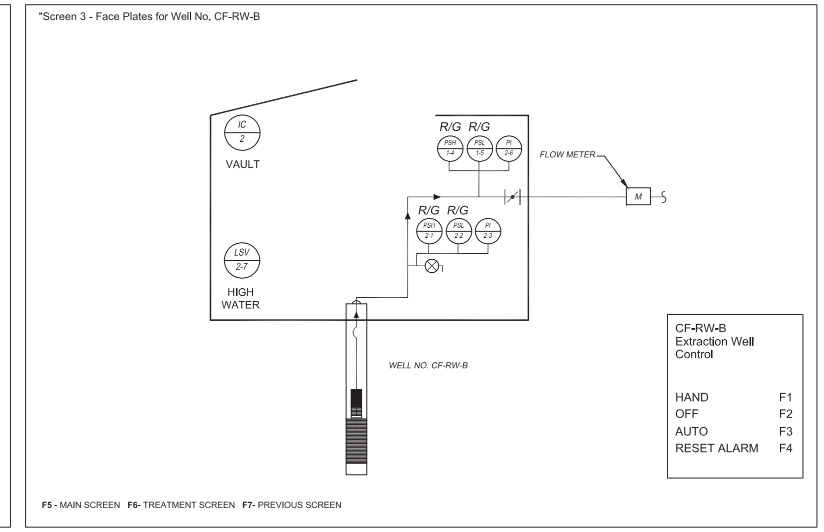
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: E–3CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			

"Screen 1 - Main Screen"

TOTAL	GPM	PUMP STATUS (HOA)	PUMP RUN TIME (HOURS)
WELL NO. CF-RW-A			
WELL NO. CF-RW-B			
WELL NO. CF-RW-C			
WELL NO. CF-RW-D			
WELL NO. CF-RW-E			
WELL NO. CF-RW-F			
WELL NO. CF-RW-G			
WELL NO. CF-RW-H			

F1 - MAIN SCREEN **F2** - WELL CF-RW-A **F3** - WELL CF-RW-B **F4** - WELL CF-RW-C **F5** - WELL CF-RW-D **F6** - WELL CF-RW-E **F7** - WELL CF-RW-F **F8** - WELL CF-RW-G **F9** - WELL CF-RW-H **F10** - ALARM LIST **F11** - TREATMENT SCREEN





LEGEND

PI = PRESSURE INDICATOR

PSH = PRESSURE SWITCH - ALARM ON HIGH

PSL = PRESSURE SWITCH - ALARM ON LOW

LSH = LEVEL SWITCH - ALARM ON HIGH WATER LEVEL IN CASING

LSB = LEVEL SWITCH - ALARM ON HIGH WATER LEVEL IN BUILDING

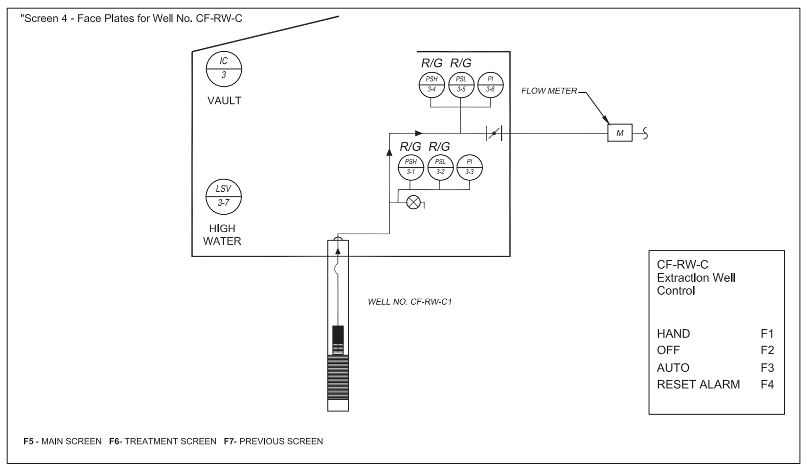
LSV = LEVEL SWITCH - ALRM ON HIGH WATER LEVEL IN WELL VAULT

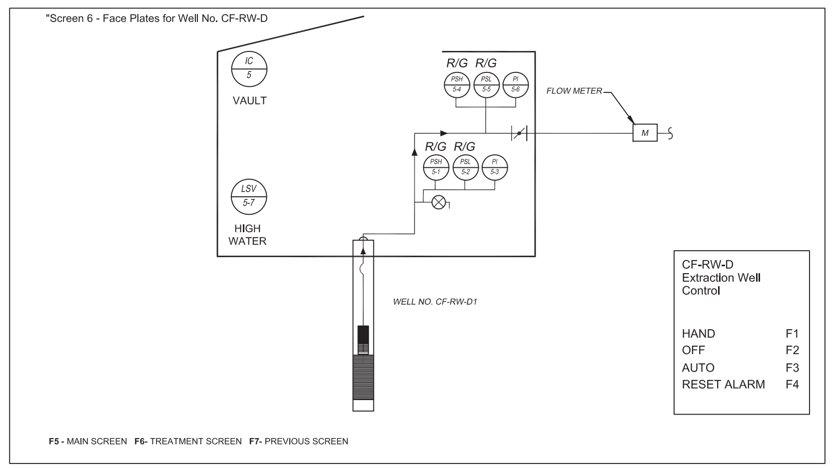
DP = DIFFERENTIAL PRESSURE SWITCH - ALARM ON HIGH

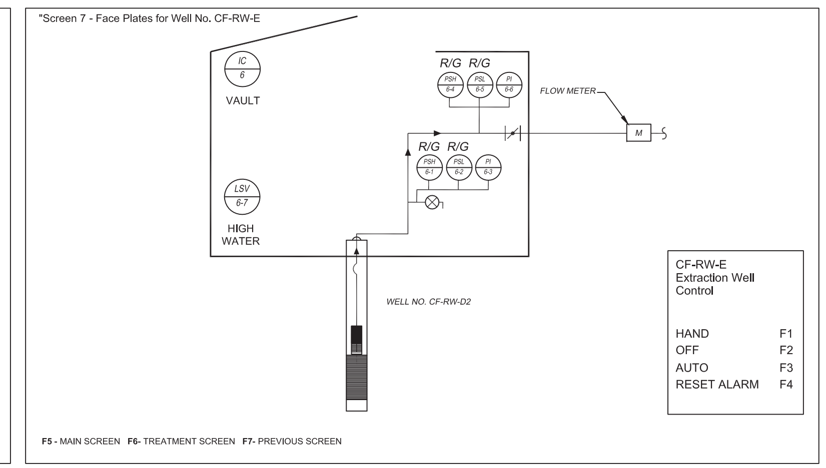
LT = LOW TEMP SENSOR

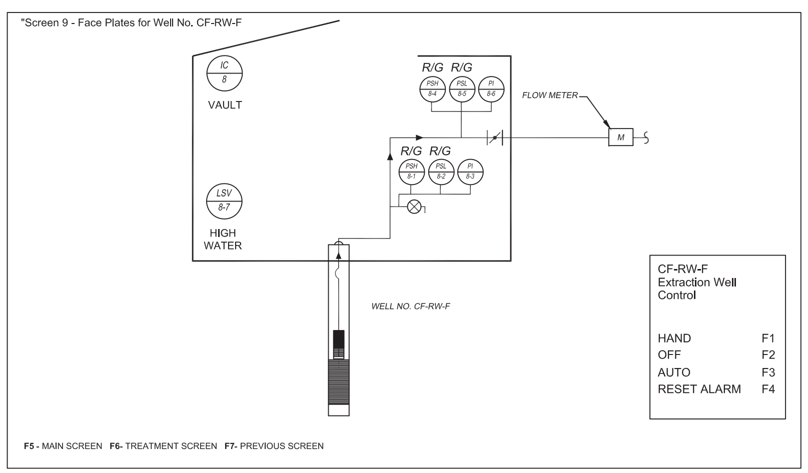
R/G = GRAPHIC OBJECT SHALL BE COLOR CODED
RED = OFF OR DOOR OPEN OR HIGH WATER, OR OUT OF RANGE
GREEN = ENERGIZED OR DOOR CLOSED OR LOW WATER
OR NORMAL RANGE

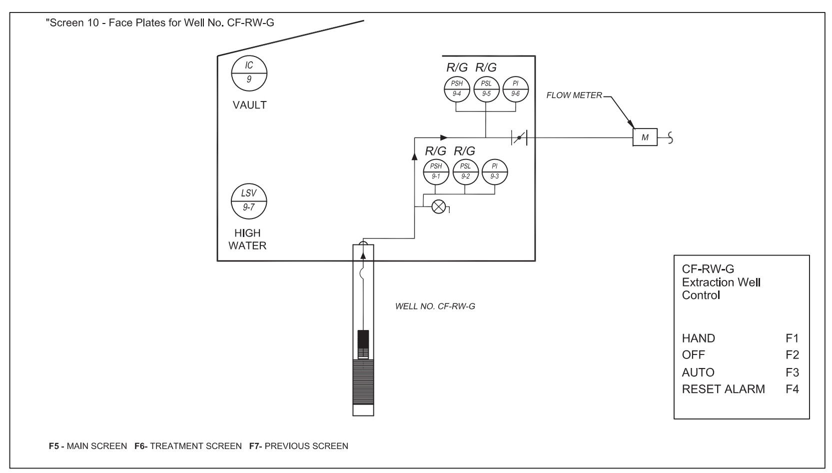
IC = INTRUSION CONTACT

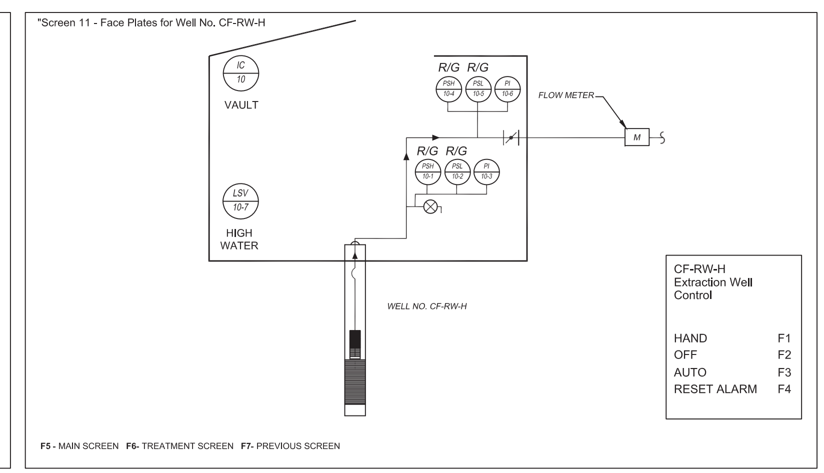












PANELVIEW DISPLAY SCREEN

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

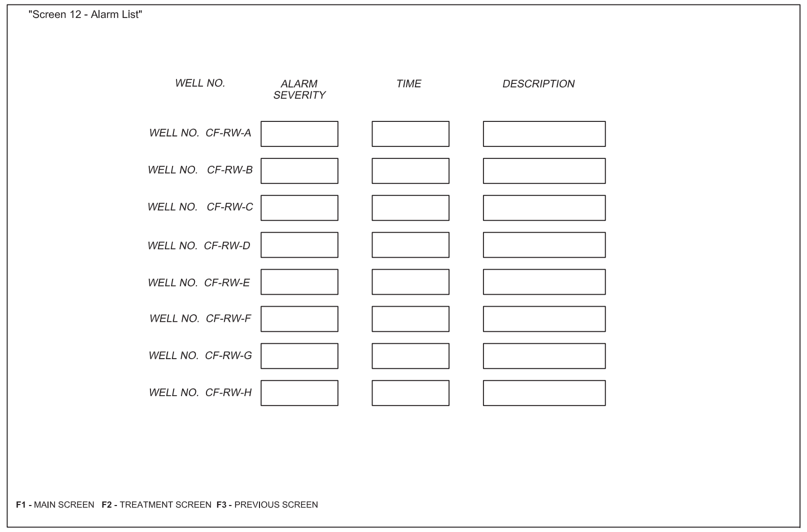
BROOKHAVEN NATIONAL LABORATORY

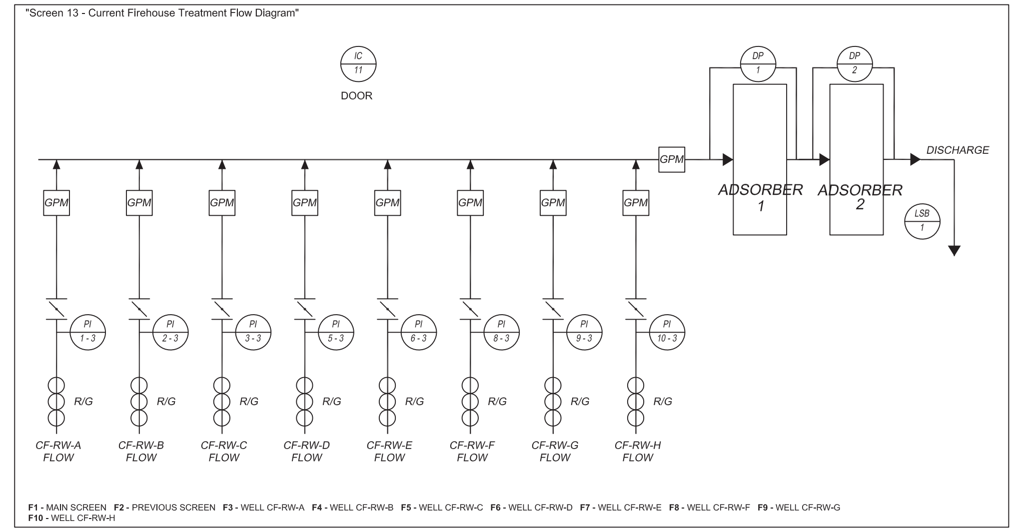
UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
ENVIRONMENTAL MANAGEMENT DIRECTORATE &
ENVIRONMENTAL PROTECTION DIVISION
UPTON, NEW YORK 11973

STATE OF NEW YORK ★ JAMES R. HOLZMACHER ★ No. 66054 LICENSED PROFESSIONAL ENGINEER

J.R. HOLZMACHER P.E., LLC
The Third Generation of Excellence In
Water Supply, Water Resources, Civil and Environmental Engineering
3555 Veterans Memorial Highway, Suite A, Ronkonkoma NY 11779
PHONE: (631) 234-2220 FAX: (631) 234-2221 E-MAIL: info@holzmacher.com

JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS – 4 OF 5	
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 11 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: E–4CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			





PANELVIEW SCREEN LAYOUT - CFH

N.T.S.

LEGEND

PI = PRESSURE INDICATOR

PSH = PRESSURE SWITCH - ALARM ON HIGH

PSL = PRESSURE SWITCH - ALARM ON LOW

LSH = LEVEL SWITCH - ALARM ON HIGH WATER LEVEL IN CASING

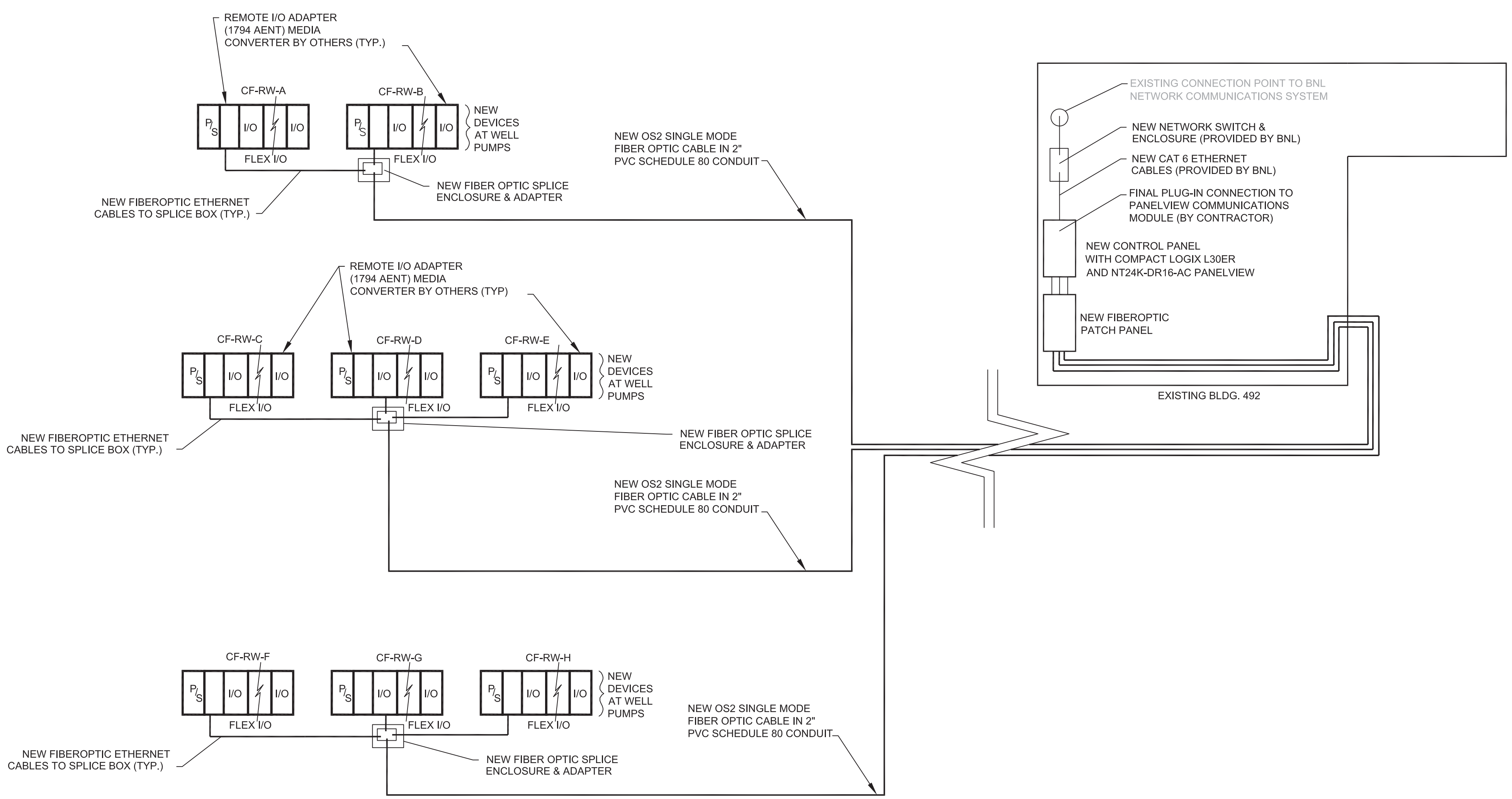
LSB = LEVEL SWITCH - ALARM ON HIGH WATER LEVEL IN BUILDING

LSV = LEVEL SWITCH - ALRM ON HIGH WATER LEVEL IN WELL VAULT

DP = DIFFERENTIAL PRESSURE SWITCH - ALARM ON HIGH

R/G = GRAPHIC OBJECT SHALL BE COLOR CODED
RED = OFF OR DOOR OPEN OR HIGH WATER, OR OUT OF RANGE
GREEN = ENERGIZED OR DOOR CLOSED OR LOW WATER
OR NORMAL RANGE

IC = INTRUSION CONTACT



COMMUNICATIONS BLOCK DIAGRAM - CFH

N.T.S.

NOTE: SEE PLAN SHEETS 31-CC-1 AND 32-CC-2 FOR COMMUNICATION AND CONTROLS DETAILS

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

BROOKHAVEN NATIONAL LABORATORY

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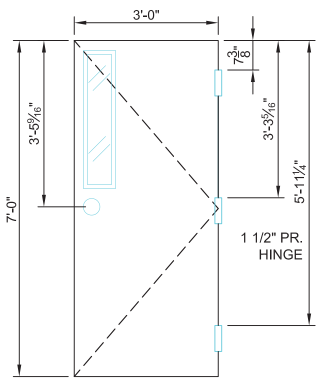
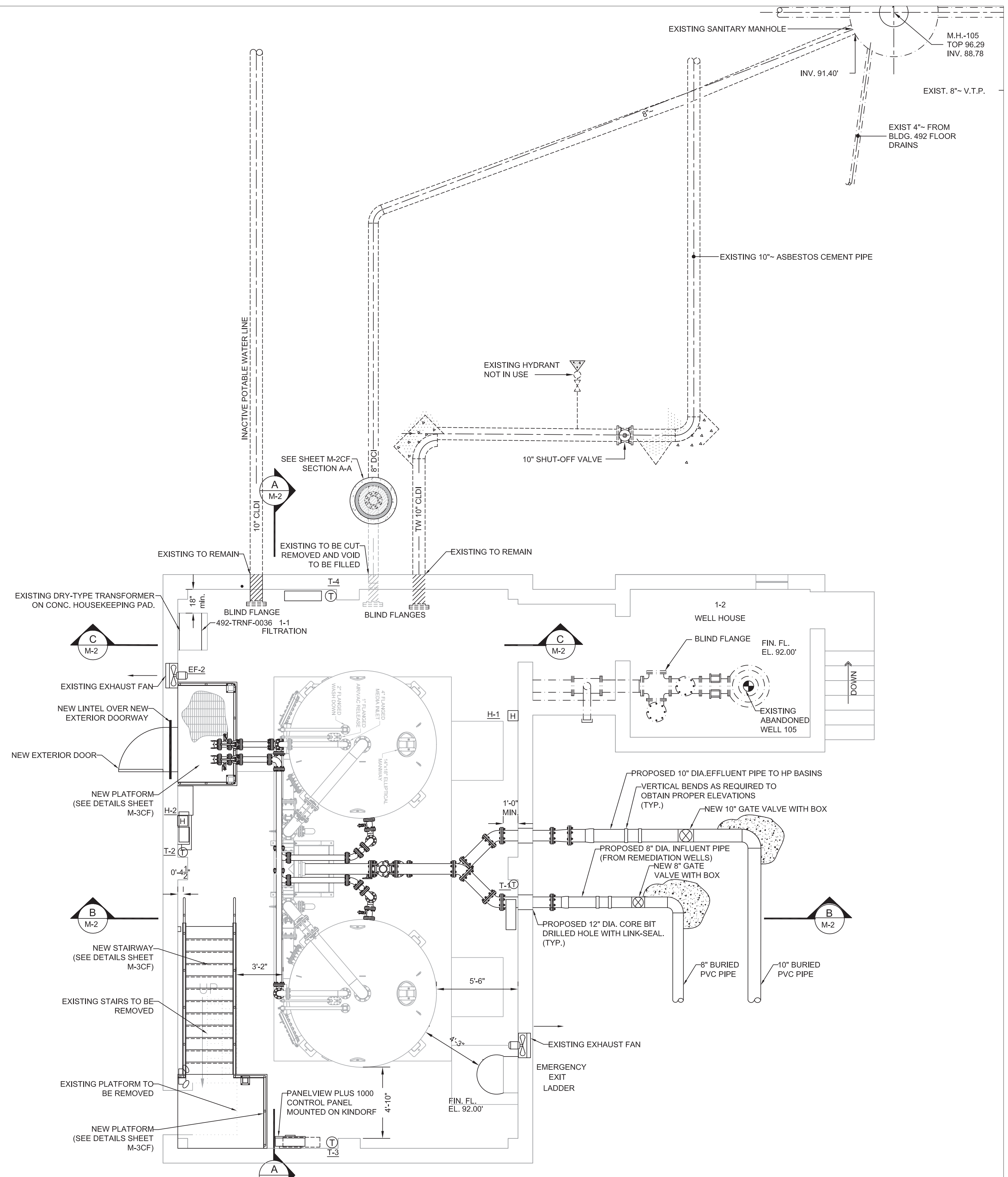
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: CURRENT FIREHOUSE ELECTRICAL AND CONTROLS DETAILS – 5 OF 5	
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 12 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: E–5CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			



FIRE RATED DOOR DETAIL

SCALE: 1/2" = 1'



EXISTING BUILDING 492 FLOOR PLAN

SCALE: 1/4" = 1'-0"

LEGEND AND SYMBOLS

UW	UNTREATED WATER
TW	TREATED WATER
BW	BACKWASH
CS	CARBON STEEL
CLDI	CEMENT LINED DUCTILE IRON
DCI	DUCTILE CAST IRON
PVC	POLYVINYL CHLORIDE
V.T.P.	VITREOUS TILE PIPE
	PART OF GAC UNIT, TO BE PROVIDED BY GAC MANUFACTURER
	EXISTING PIPE (ABOVE AND BELOW GRADE) TO REMAIN
	NEW PIPE
	NEW PIPE RUN BELOW GRADE AND/OR SLAB
	EXISTING PIPE TO BE REMOVED
T	THERMOSTAT
H	HUMIDISTAT
RD	ROOF DRAIN

GENERAL NOTES:

1. RESTRAIN ALL JOINTS AS SPECIFIED AND AS SHOWN.
2. ALL EXPOSED FIELD PIPING SHALL BE POWER TOOL CLEANED AND FINISHED WITH EXTERIOR PAINTING OF AN EPOXY MASTIC COATING SYSTEM FOR OUTSIDE SERVICE. THE TWO COAT SYSTEM SHALL BE A TOTAL OF 6 MIL DFT OF SHERWIN WILLIAMS B58 SERIES COATING, CONSISTING OF HIGH SOLIDS POLYAMINE/BISPHENOL A EPOXY FORMULATION.
3. CONTRACTOR TO COMPLETE INSTALLATION OF EXISTING CARBON VESSELS, VALVE TREE AND ASSOCIATED PIPING AND SECURE VESSELS TO THE SLAB.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA
		1					

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STATE OF NEW YORK · JAMES R. HOLZMACHER · No. 66054 · LICENSED PROFESSIONAL ENGINEER

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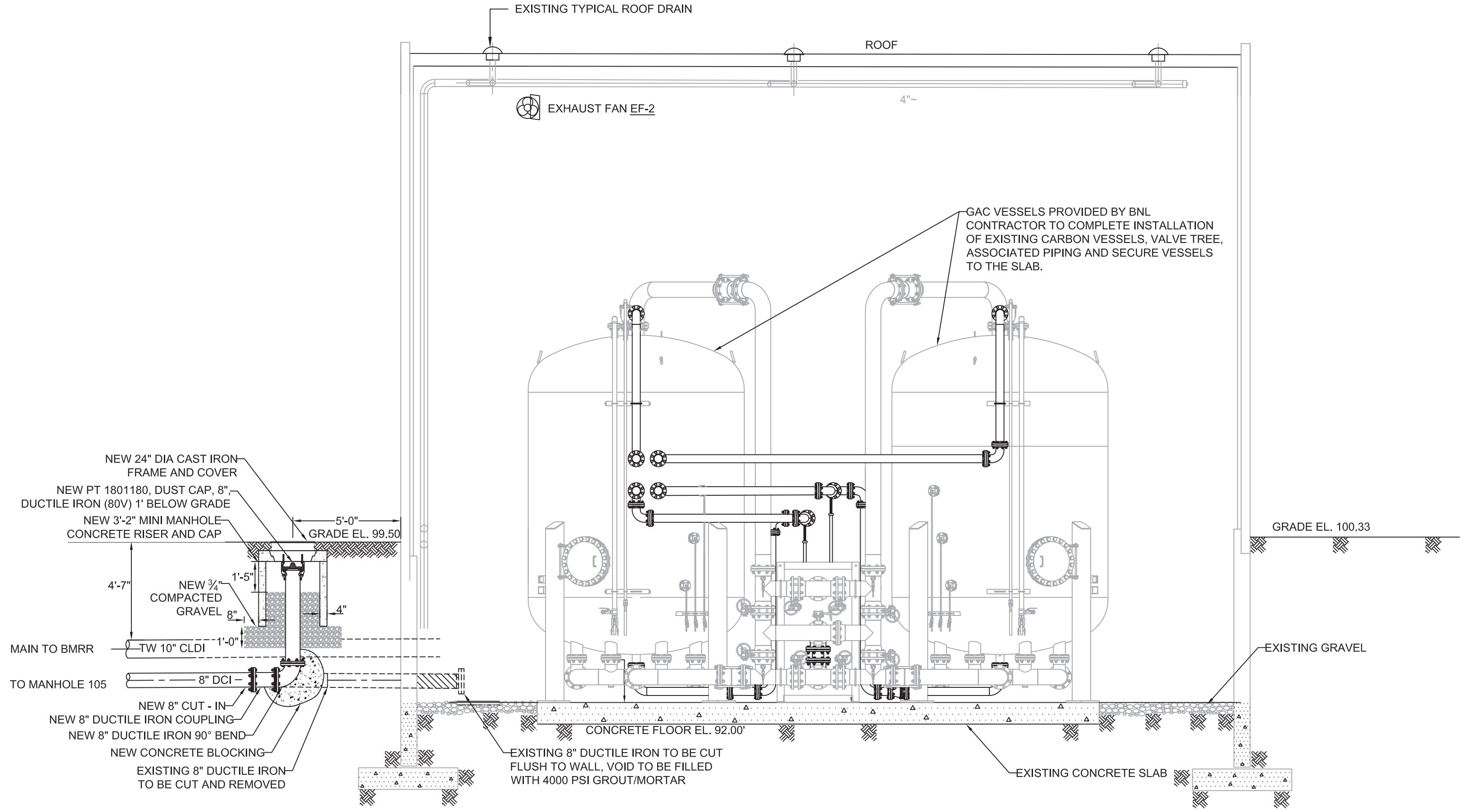
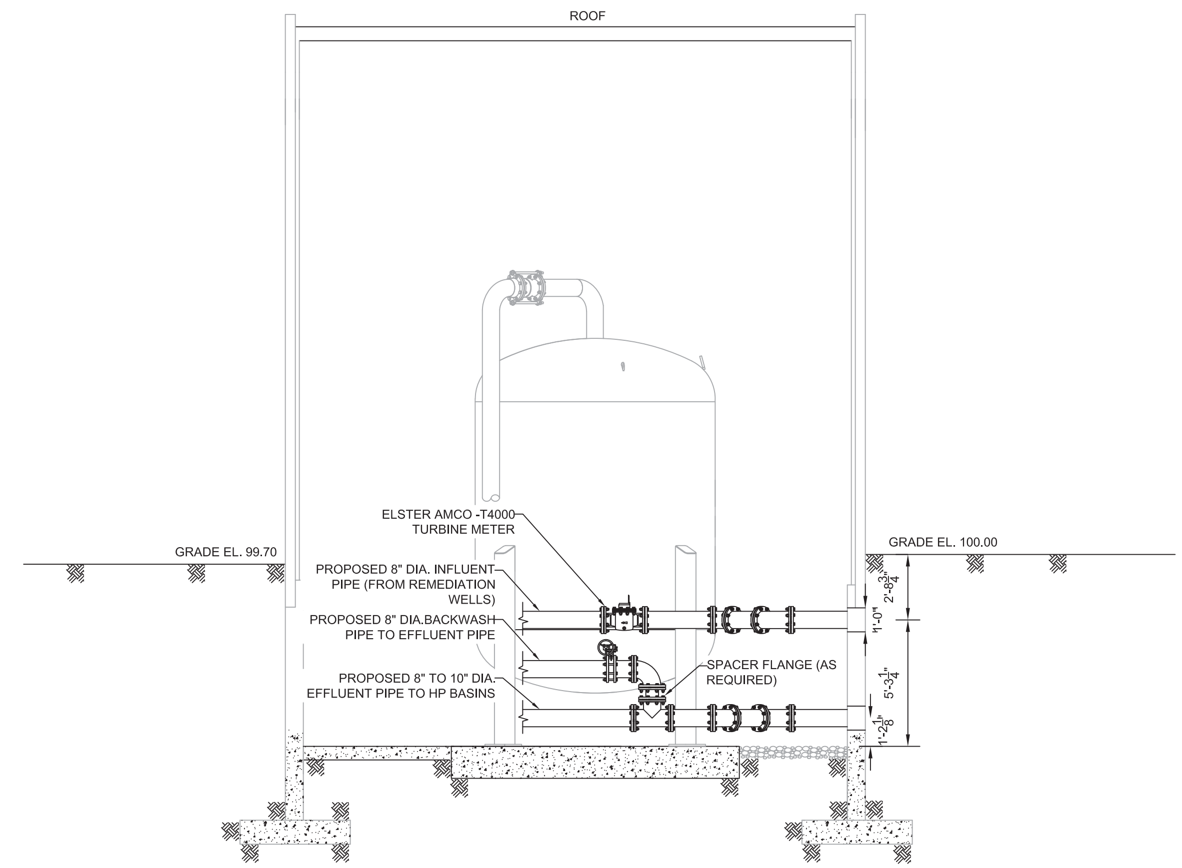
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 13 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: M–1CF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: 492	
PATH: –			



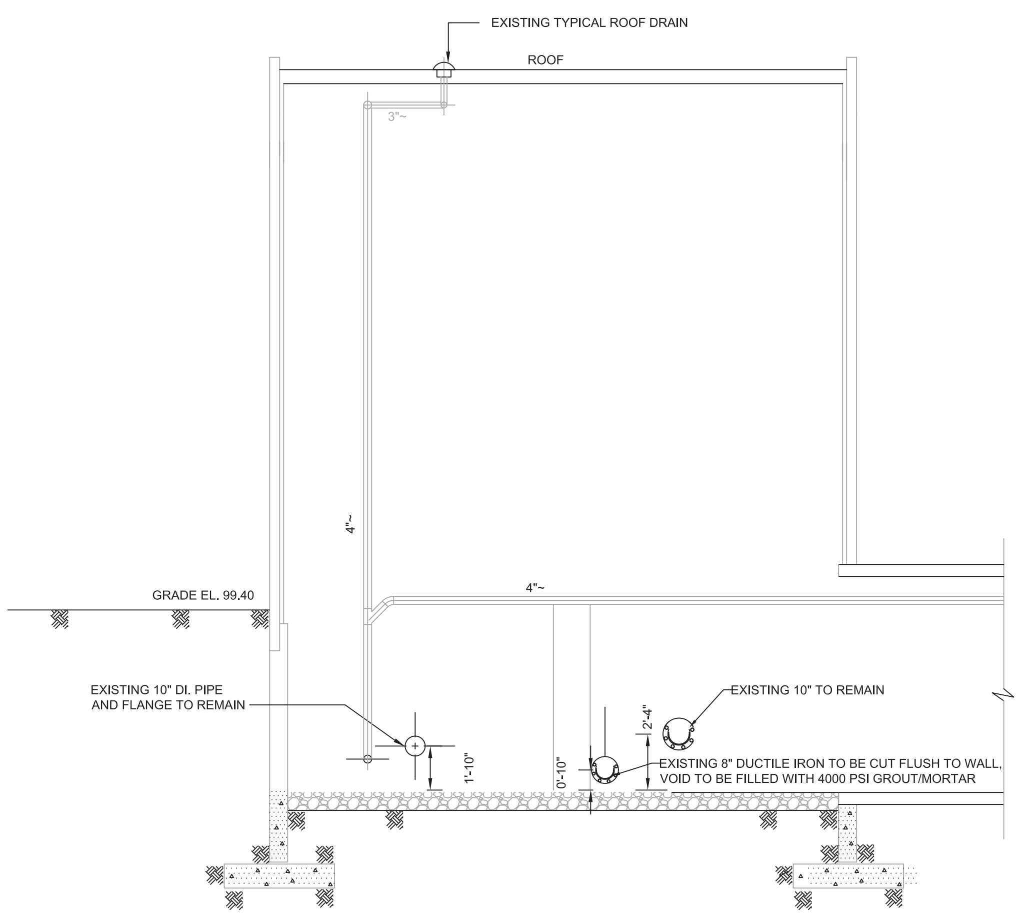
SECTION A-A

SCALE 1/4"=1'-0"



SECTION B-B

SCALE 1/4"=1'-0"



SECTION C-C

SCALE 1/4"=1'-0"

BUILDING 492 SECTIONS

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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UPTON, NEW YORK 11973

J.R. HOLZMACHER P.E., LLC

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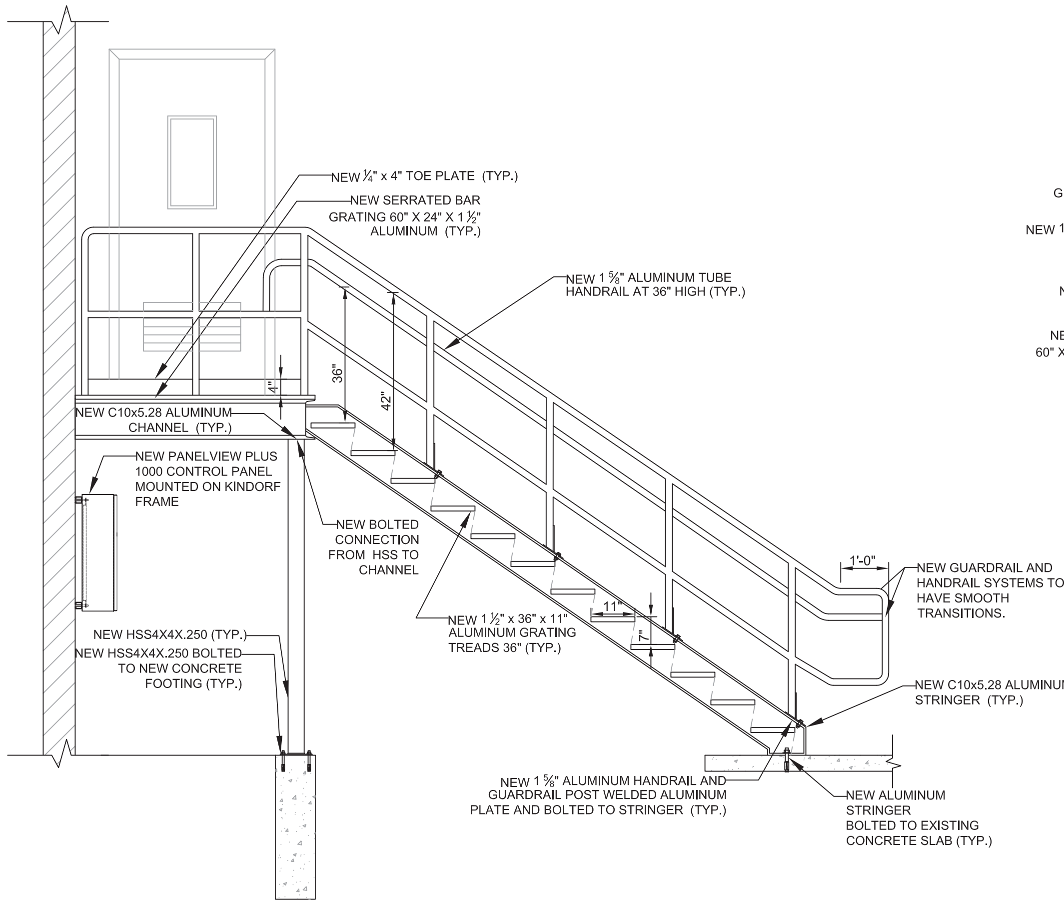
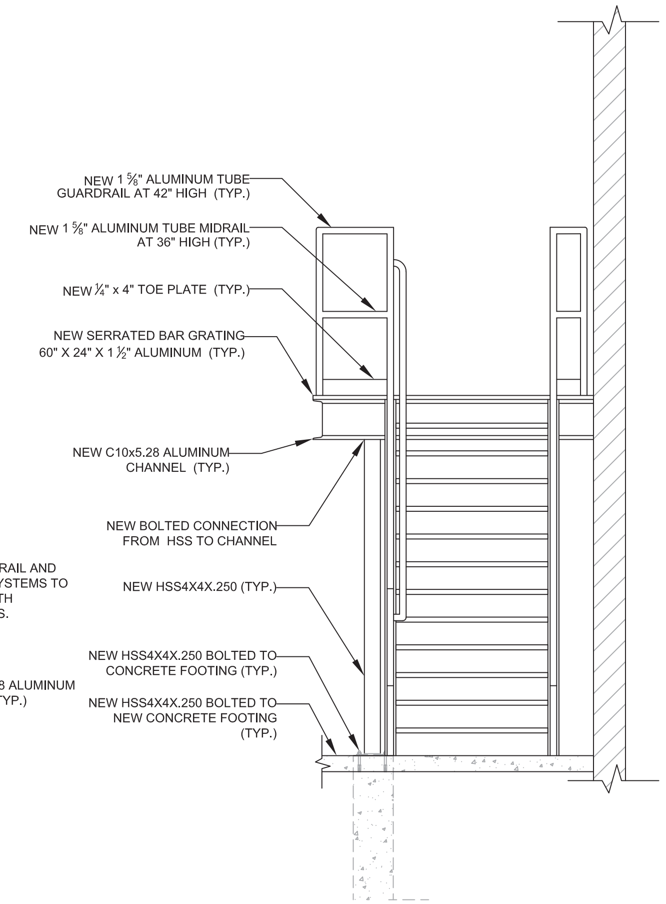
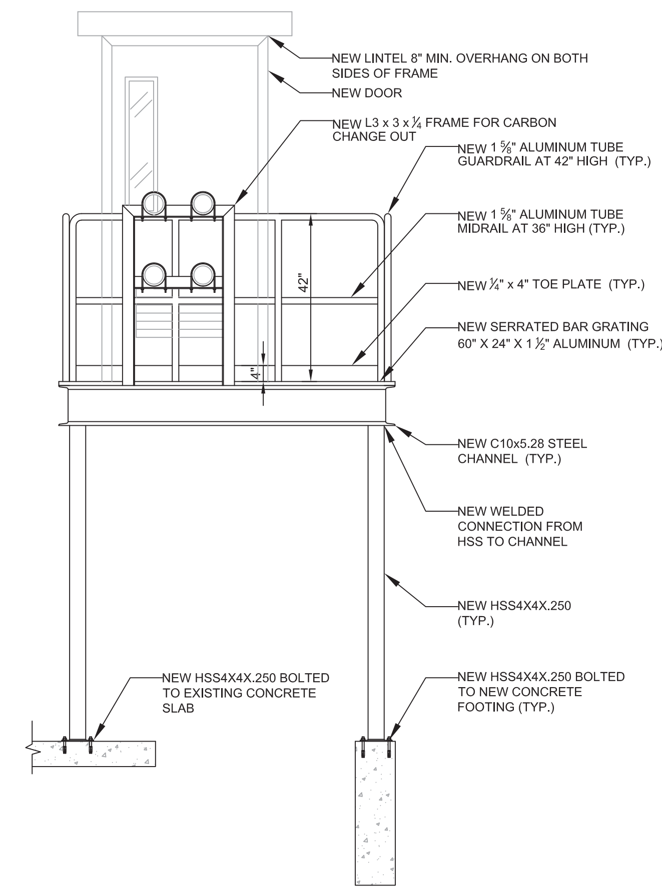
JOB TITLE PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE CURRENT FIREHOUSE MECHANICAL DETAILS – 2 OF 3	
ILR,GPP,LNI, HEW –	DATE 4/1/2021	ACCT. NO. 21097	SHEET 14 OF 33
SCALE AS SHOWN	DWN. BY AJZ	JOB NO. 14011	DWG. NO. M-2CF
PROJ. QA A3–MINOR	APP'D. BY JRH	BLDG. NO. 492	
PATH: –			



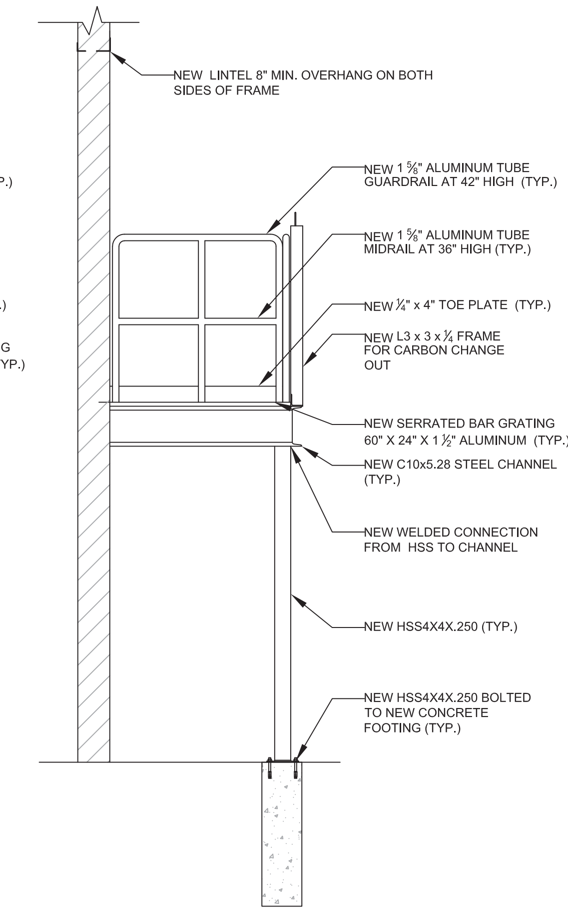
STAIR SIDE ELEVATION
SCALE: 1/2" = 1'



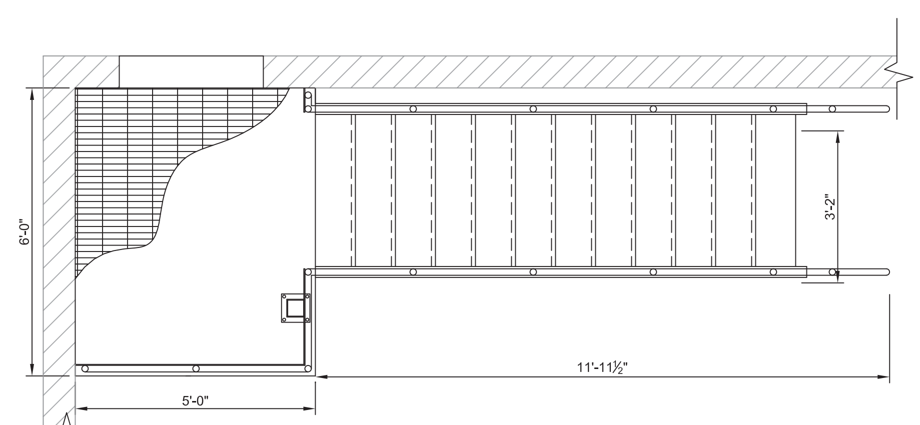
STAIR FRONT ELEVATION
SCALE: 1/2" = 1'



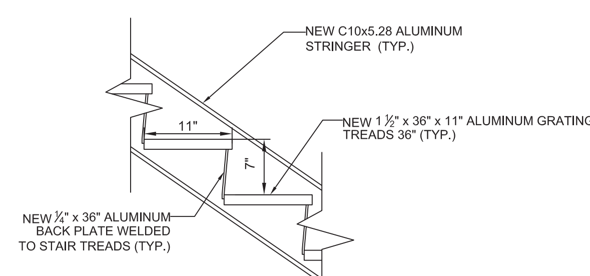
PLATFORM FRONT ELEVATION
SCALE: 1/2" = 1'



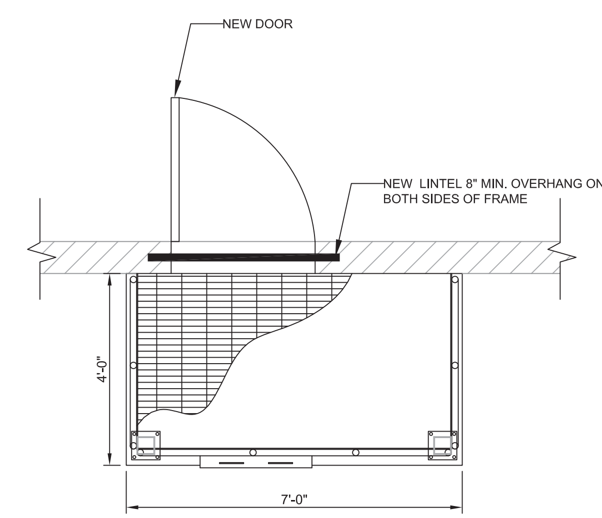
PLATFORM SIDE ELEVATION
SCALE: 1/2" = 1'



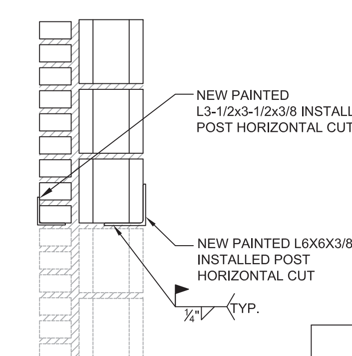
STAIR PLAN VIEW
SCALE: 1/2" = 1'



STAIR DETAIL
SCALE: 1" = 1'



PLATFORM PLAN VIEW
SCALE: 1/2" = 1'



NEW DOOR LINTEL DETAIL
SCALE: 1" = 1'

FINAL DESIGN

NEW STAIR, PLATFORM, AND DOOR INSTALLATION DETAILS
SCALE: AS NOTED

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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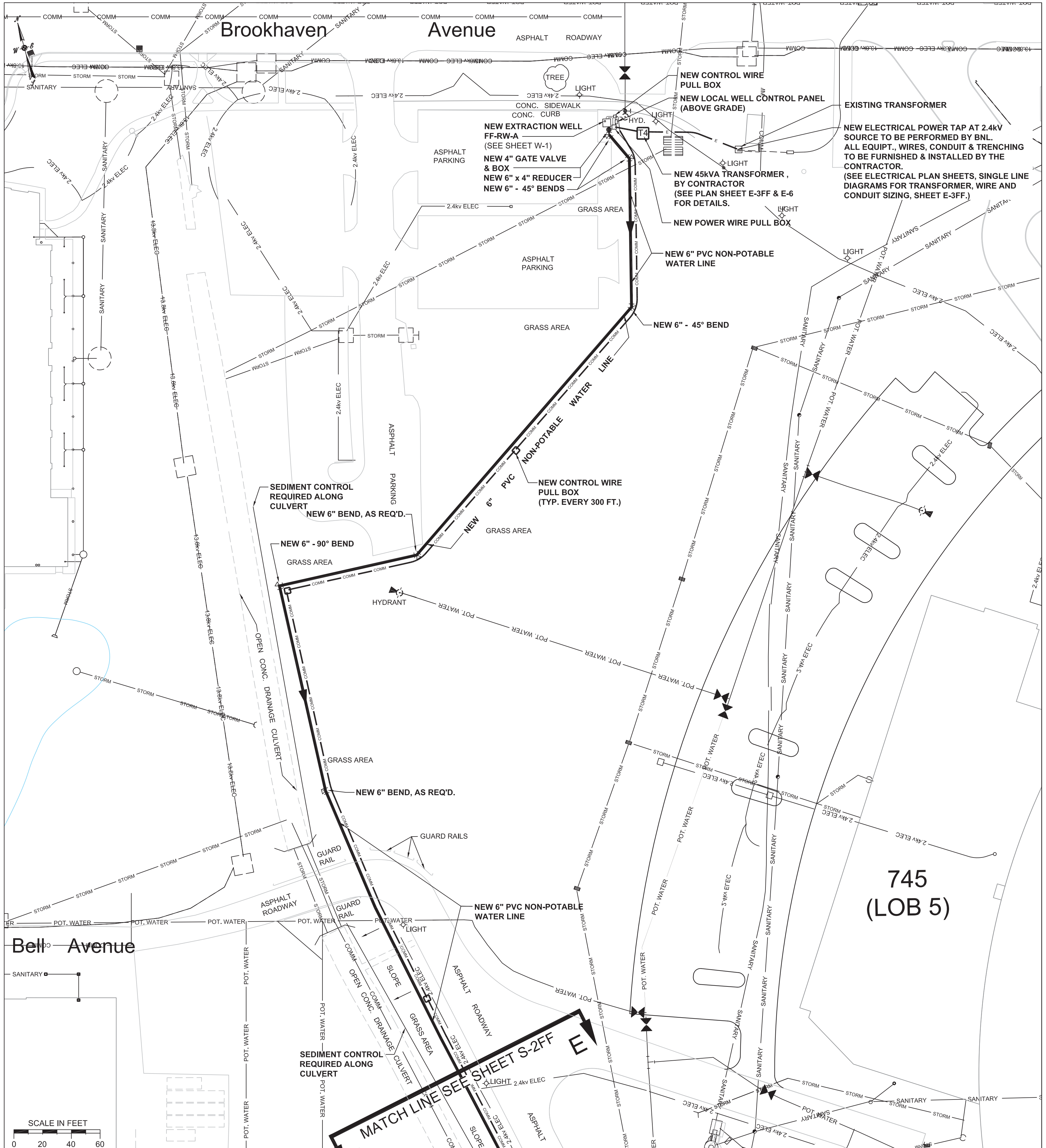
ENVIRONMENTAL MANAGEMENT DIRECTORATE & ENVIRONMENTAL PROTECTION DIVISION
UPTON, NEW YORK 11973

JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: CURRENT FIREHOUSE MECHANICAL DETAILS – 3 OF 3	
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 15 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: M-3CF
PROJ. QA: A3-MINOR	APP'D. BY: JRH	BLDG. NO.: 492	
PATH: –			

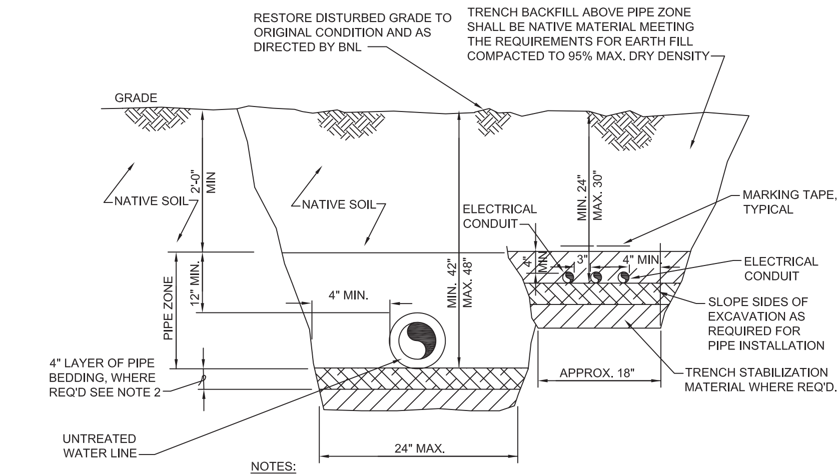
J.R. HOLZMACHER P.E., LLC
The Third Generation of Excellence in Water Supply, Water Resources, Civil and Environmental Engineering
3555 Veterans Memorial Highway, Suite A, Ronkonkoma NY 11779



FORMER FIREHOUSE SITE PLAN - 1 OF 4

SCALE: 1" = 40'

NOTE: TO HAND DIG TO VERIFY THE PRESENCE OR ABSENCE OF ACTIVE OR ABANDONED UNDERGROUND UTILITIES



NOTES:

1. PROVIDE 12" MINIMUM SEPARATION BETWEEN ELECTRICAL CONDUITS AND WATER PIPES.
2. IF FIELD ENGINEER CONCURS THAT EXISTING SUBGRADE MEETS REQUIREMENTS FOR PIPE BEDDING, TRENCH BACKFILL, NO EXCAVATION BELOW PIPE ZONE IS REQUIRED. PREPARATION OF TRENCH BOTTOM/ BEDDING MATERIAL SHALL CONFORM TO ANSI/ASTM D1557 STANDARDS.
3. CONTRACTOR TO DESIGNATE A COMPETENT PERSON FOR ALL TRENCHING AND EXCAVATION OPERATIONS,THIS PERSON MUST HAVE AUTHORITY TO TAKE PROMPT CORRECTIVE ACTION TO CORRECT WORK PLACE HAZARDS.

TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA
		1					

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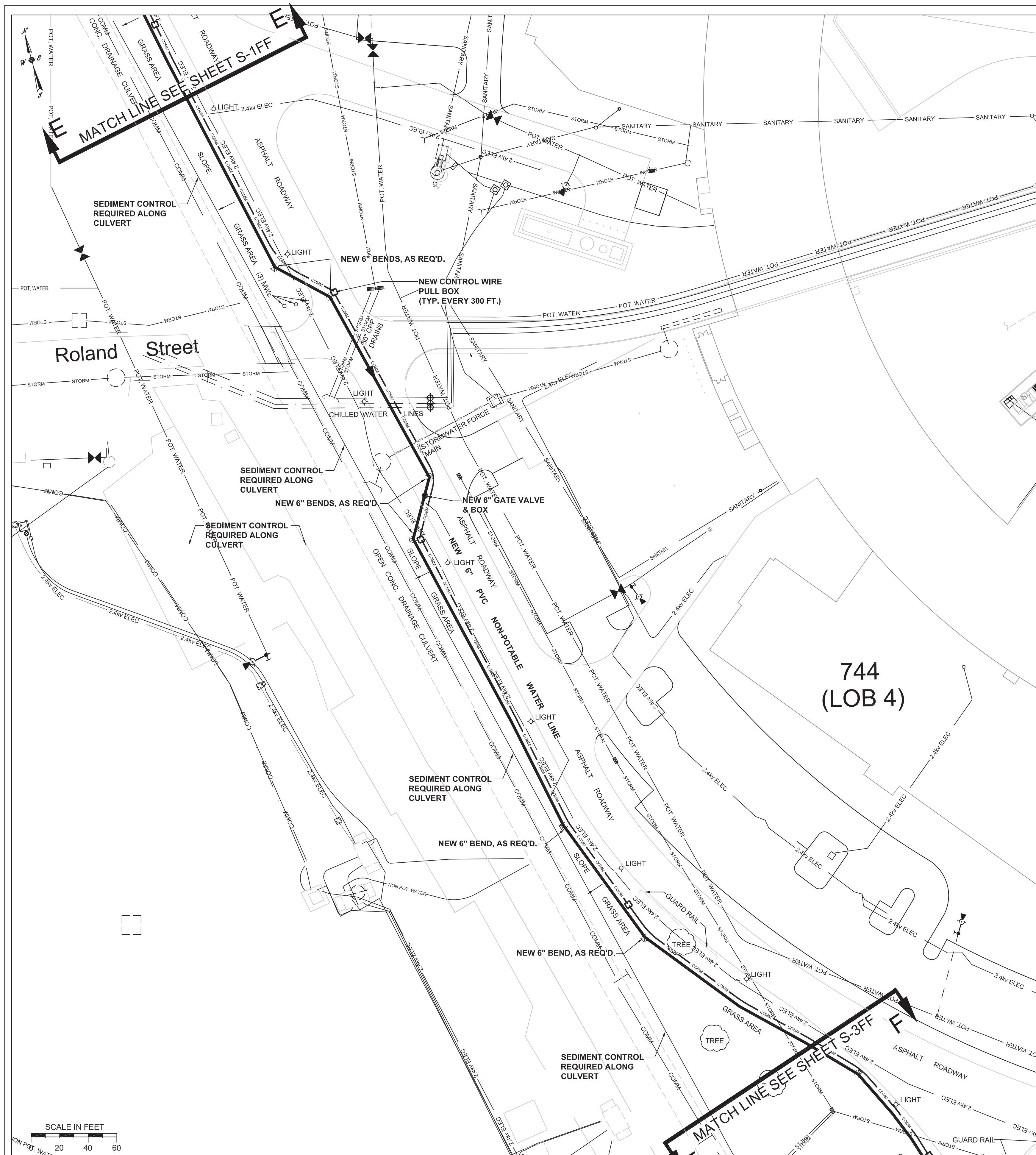
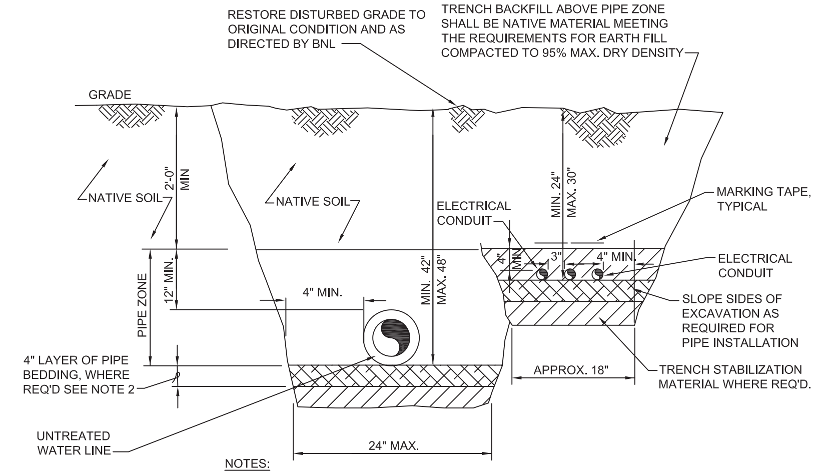
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 16 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: S–1FF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			



FORMER FIREHOUSE SITE PLAN - 2 OF 4

SCALE: 1" = 40'

NOTE: CONTRACTOR TO HAND DIG TO VERIFY THE PRESENCE OR ABSENCE OF ACTIVE OR ABANDONED UNDERGROUND UTILITIES

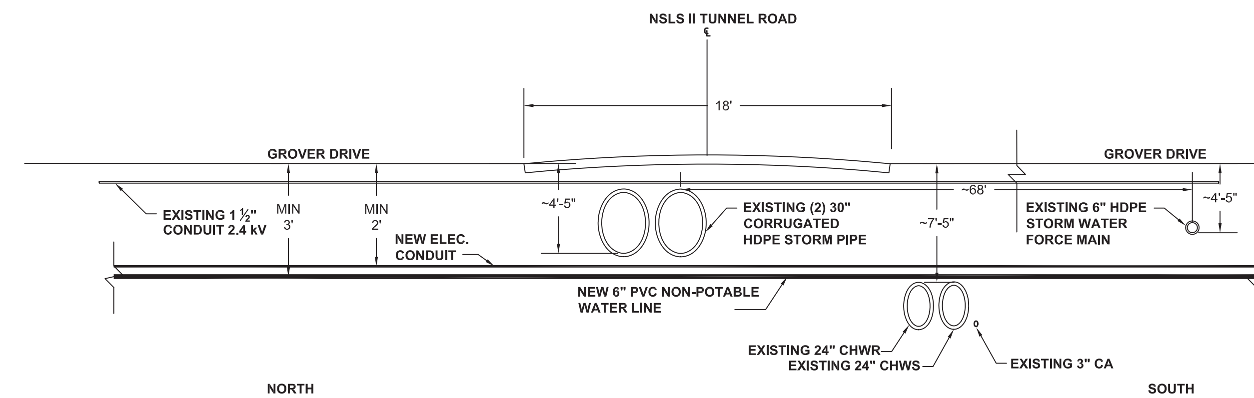


NOTES:

1. PROVIDE 12" MINIMUM SEPARATION BETWEEN ELECTRICAL CONDUITS AND WATER PIPES.
2. IF FIELD ENGINEER CONCURS THAT EXISTING SUBGRADE MEETS REQUIREMENTS FOR PIPE BEDDING, TRENCH BACKFILL, NO EXCAVATION BELOW PIPE ZONE IS REQUIRED, PREPARATION OF TRENCH BOTTOM/ BEDDING MATERIAL SHALL CONFORM TO ANSI/ASTM D1557 STANDARDS.
3. CONTRACTOR TO DESIGNATE A COMPETENT PERSON FOR ALL TRENCHING AND EXCAVATION OPERATIONS,THIS PERSON MUST HAVE AUTHORITY TO TAKE PROMPT CORRECTIVE ACTION TO CORRECT WORK PLACE HAZARDS.

TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.



GROVER RD. ROAD SECTION

SCALE: N.T.S.

(INTERSECTION OF GROVER RD. AND ROLAND ST.)

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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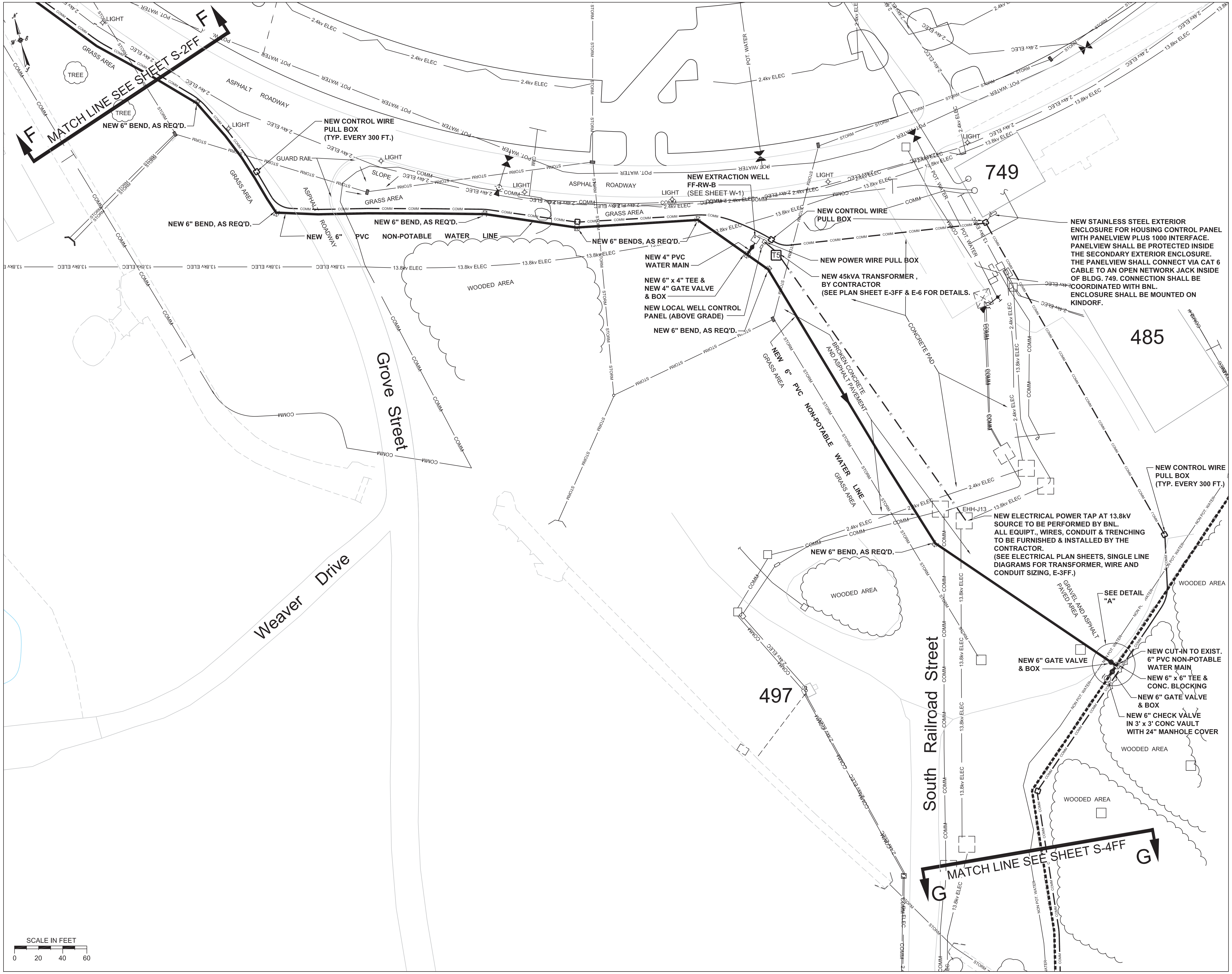
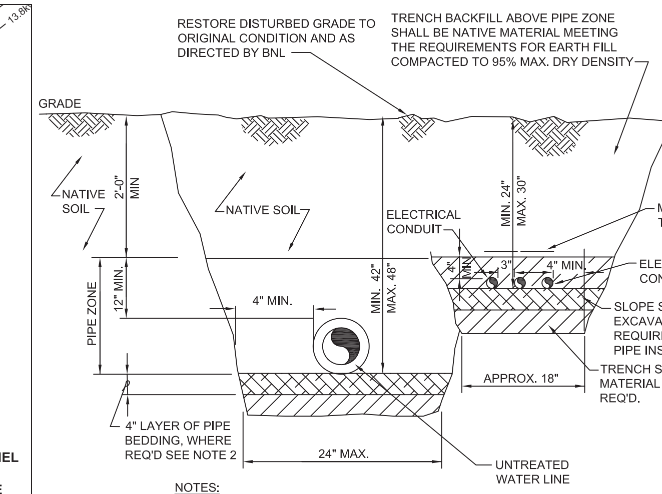
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 17 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: S-2FF
PROJ. QA: A3-MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			



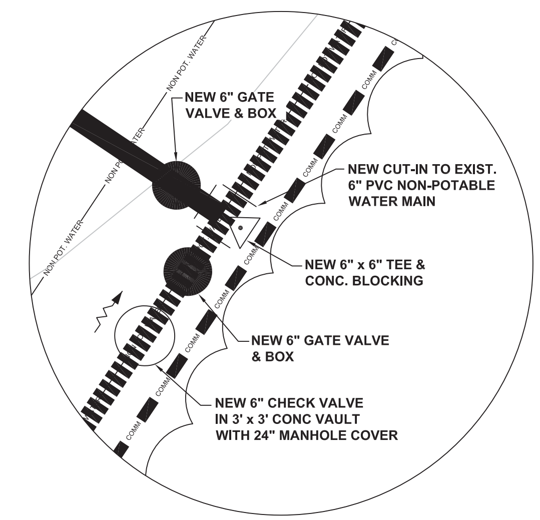
FORMER FIREHOUSE SITE PLAN - 3 OF 4
SCALE: 1" = 40'



NOTES:

1. PROVIDE 12" MINIMUM SEPARATION BETWEEN ELECTRICAL CONDUITS AND WATER PIPES.
2. IF FIELD ENGINEER CONCURS THAT EXISTING SUBGRADE MEETS REQUIREMENTS FOR PIPE BEDDING, TRENCH BACKFILL, NO EXCAVATION BELOW PIPE ZONE IS REQUIRED. PREPARATION OF TRENCH BOTTOM/ BEDDING MATERIAL SHALL CONFORM TO ANSI/ASTM D1557 STANDARDS.
3. CONTRACTOR TO DESIGNATE A COMPETENT PERSON FOR ALL TRENCHING AND EXCAVATION OPERATIONS,THIS PERSON MUST HAVE AUTHORITY TO TAKE PROMPT CORRECTIVE ACTION TO CORRECT WORK PLACE HAZARDS.

TYPICAL NEW UTILITY TRENCH DETAIL
N.T.S.



DETAIL-A
N.T.S.

FINAL DESIGN

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ENVIRONMENTAL MANAGEMENT DIRECTORATE & ENVIRONMENTAL PROTECTION DIVISION
UPTON, NEW YORK 11973

JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: FORMER FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) - 3 OF 4	
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 18 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: S-3FF
PROJ. QA: A3-MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			

STATE OF NEW YORK · JAMES R. HOLZMACHER · No. 66054 · LICENSED PROFESSIONAL ENGINEER

J.R. HOLZMACHER P.E., LLC
The Third Generation of Excellence in Water Supply, Water Resources, Civil and Environmental Engineering
3555 Veterans Memorial Highway, Suite A, Ronkonkoma NY 11779

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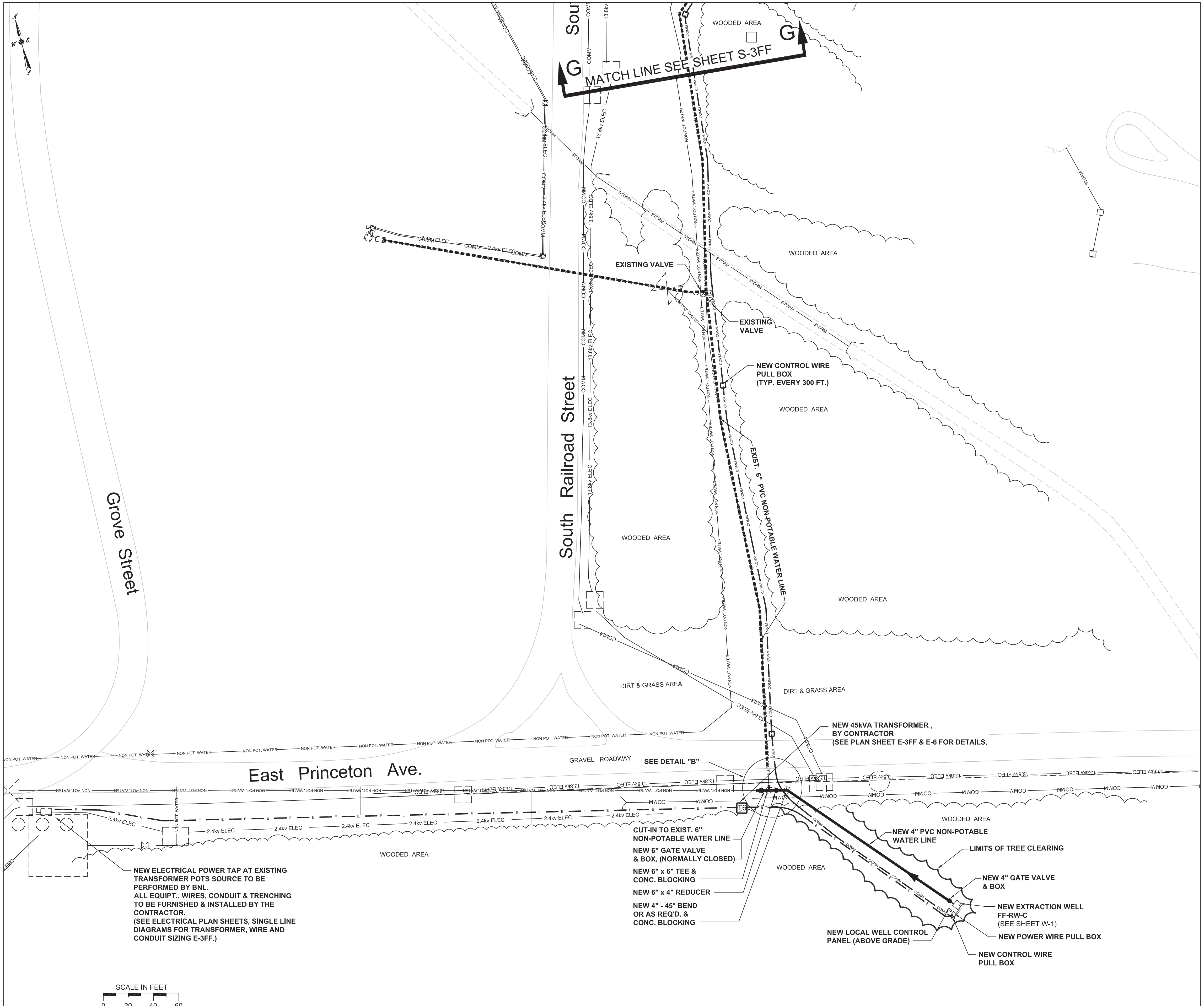
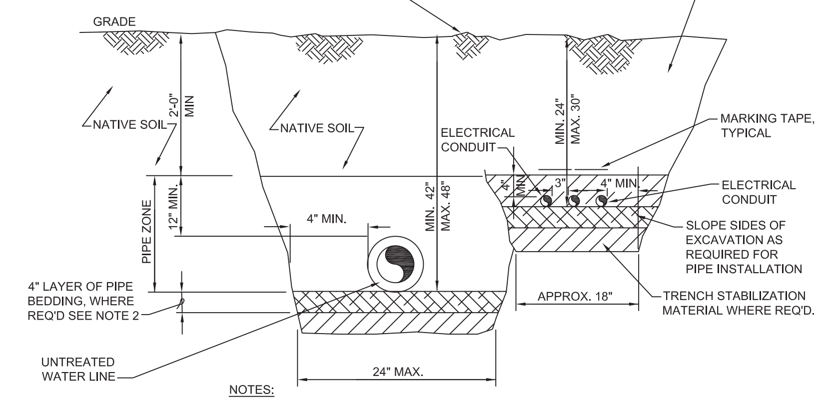
NOTE: CONTRACTOR TO HAND DIG TO VERIFY THE PRESENCE OR ABSENCE OF ACTIVE OR ABANDONED UNDERGROUND UTILITIES



FORMER FIREHOUSE SITE PLAN - 4 OF 4

SCALE: 1" = 40'

NOTE: CONTRACTOR TO HAND DIG TO VERIFY THE PRESENCE OR ABSENCE OF ACTIVE OR ABANDONED UNDERGROUND UTILITIES

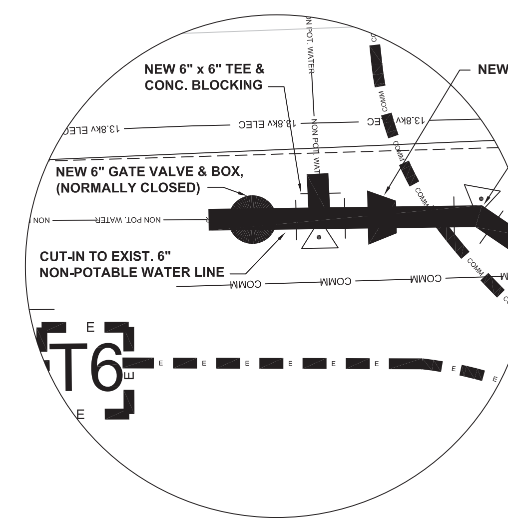


NOTES:

1. PROVIDE 12" MINIMUM SEPARATION BETWEEN ELECTRICAL CONDUITS AND WATER PIPES.
2. IF FIELD ENGINEER CONCURS THAT EXISTING SUBGRADE MEETS REQUIREMENTS FOR PIPE BEDDING, TRENCH BACKFILL, NO EXCAVATION BELOW PIPE ZONE IS REQUIRED, PREPARATION OF TRENCH BOTTOM/ BEDDING MATERIAL SHALL CONFORM TO ANSI/ASTM D1557 STANDARDS.
3. CONTRACTOR TO DESIGNATE A COMPETENT PERSON FOR ALL TRENCHING AND EXCAVATION OPERATIONS,THIS PERSON MUST HAVE AUTHORITY TO TAKE PROMPT CORRECTIVE ACTION TO CORRECT WORK PLACE HAZARDS.

TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.



DETAIL B

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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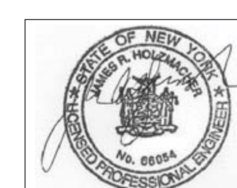
UPTON, NEW YORK 11973



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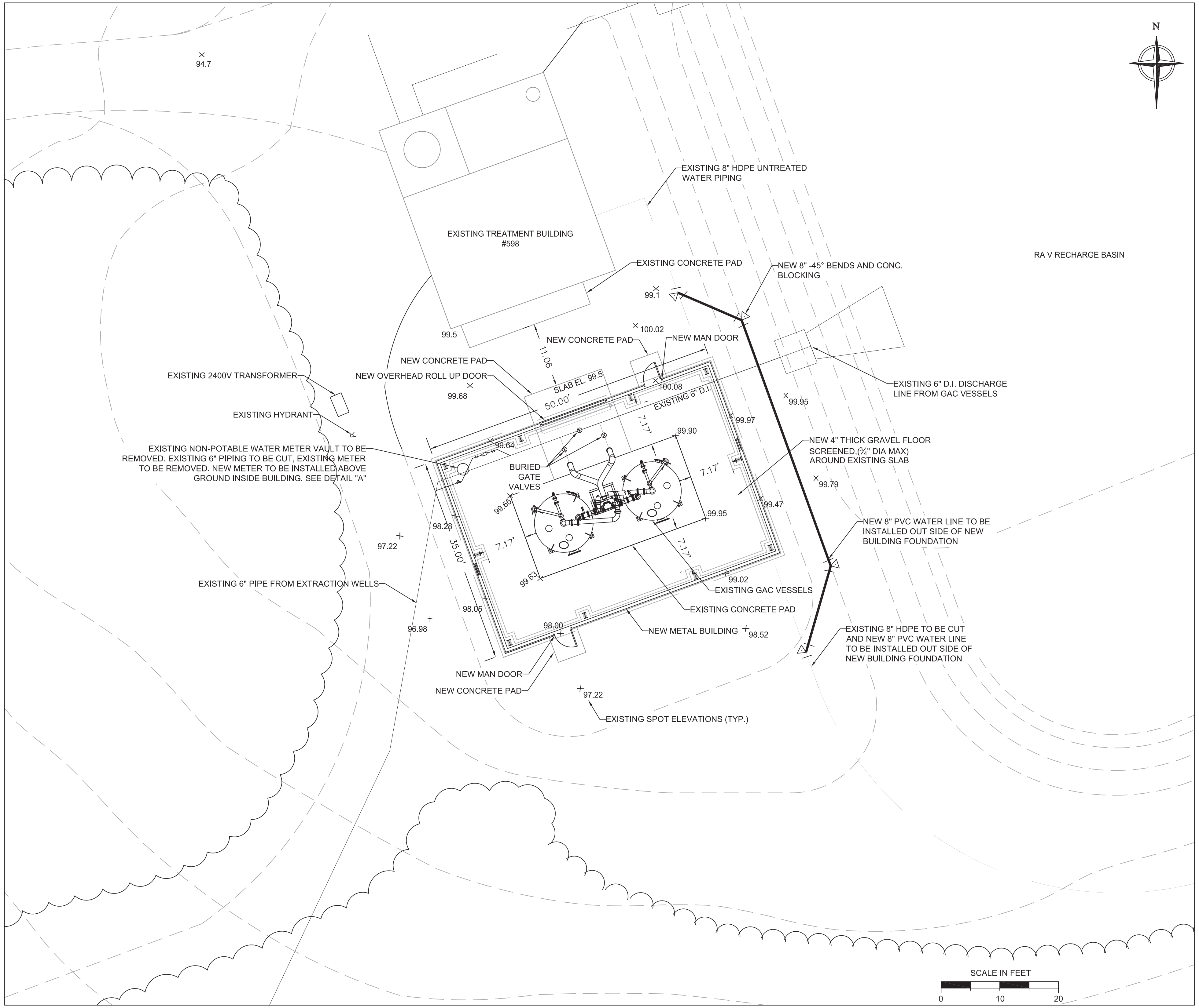
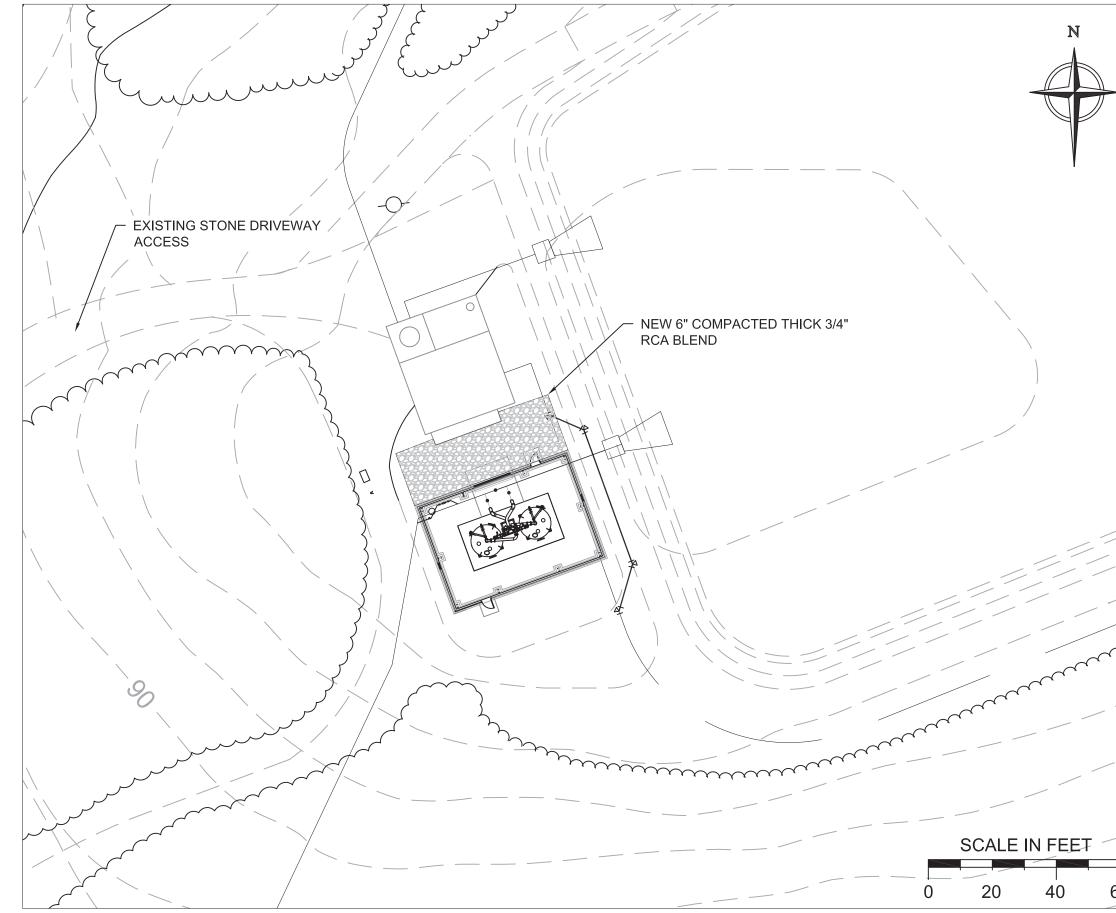
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: FORMER FIREHOUSE SITE PLAN (MECHANICAL & ELECTRICAL) – 4 OF 4	
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 19 OF 32
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: S-4FF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH: –			



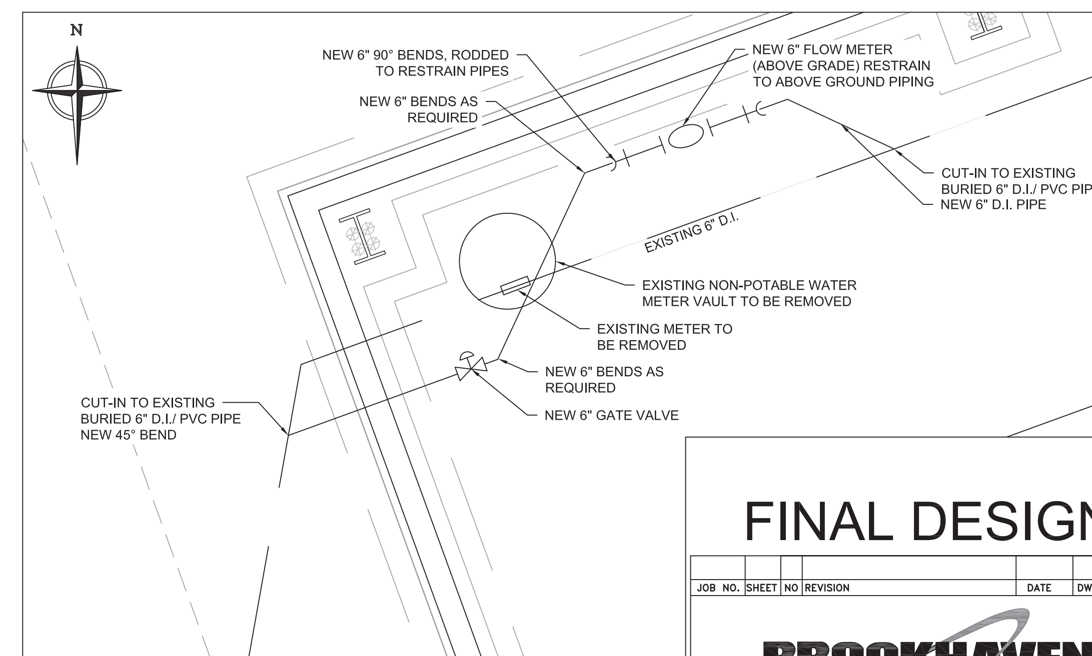
NEW BUILDING SITE PLAN

SCALE: 1" = 10'



RAV BASIN LOCATION MAP

SCALE: 1" = 30'



DETAIL A NEW WATER METER INSTALLATION

N.T.S

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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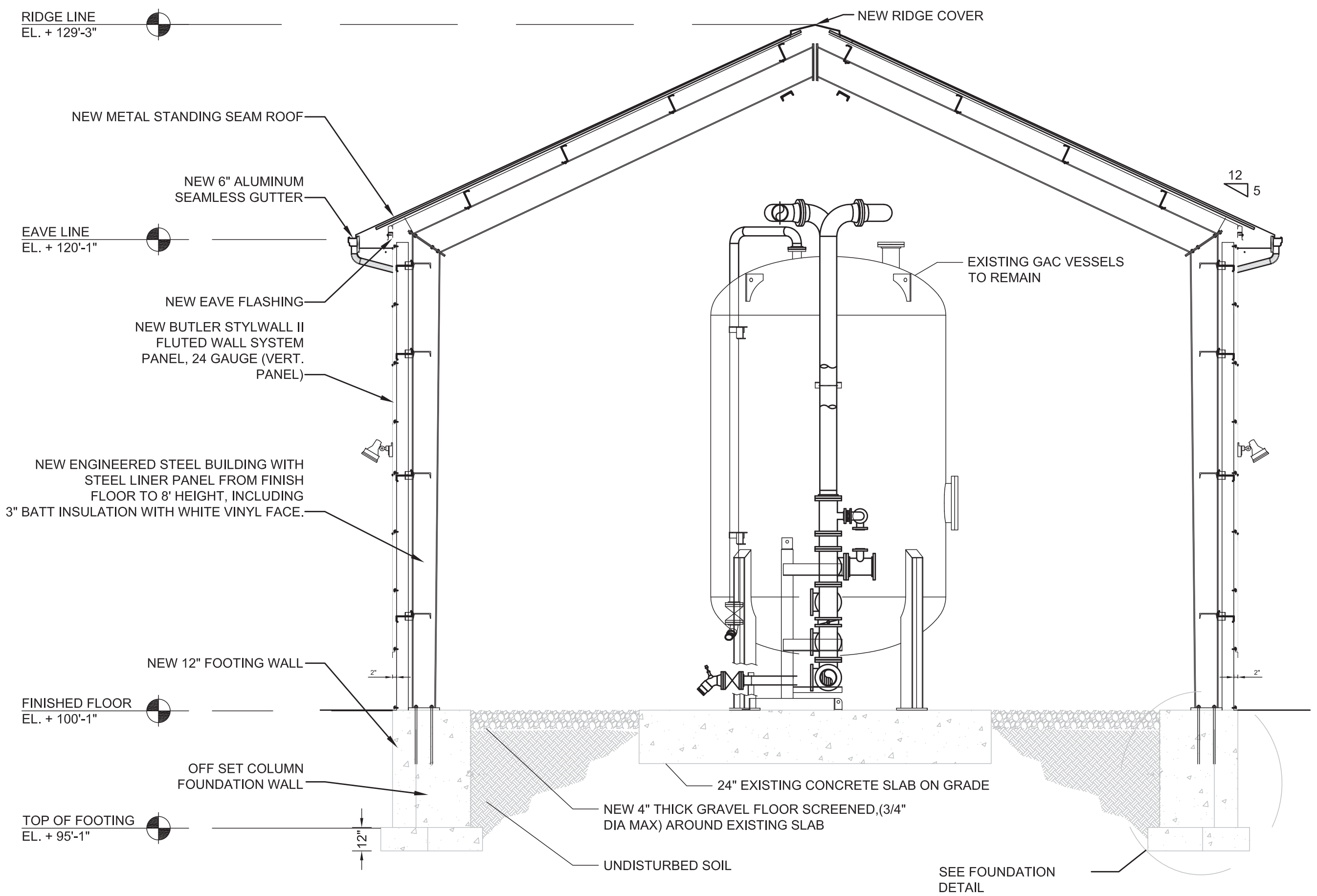
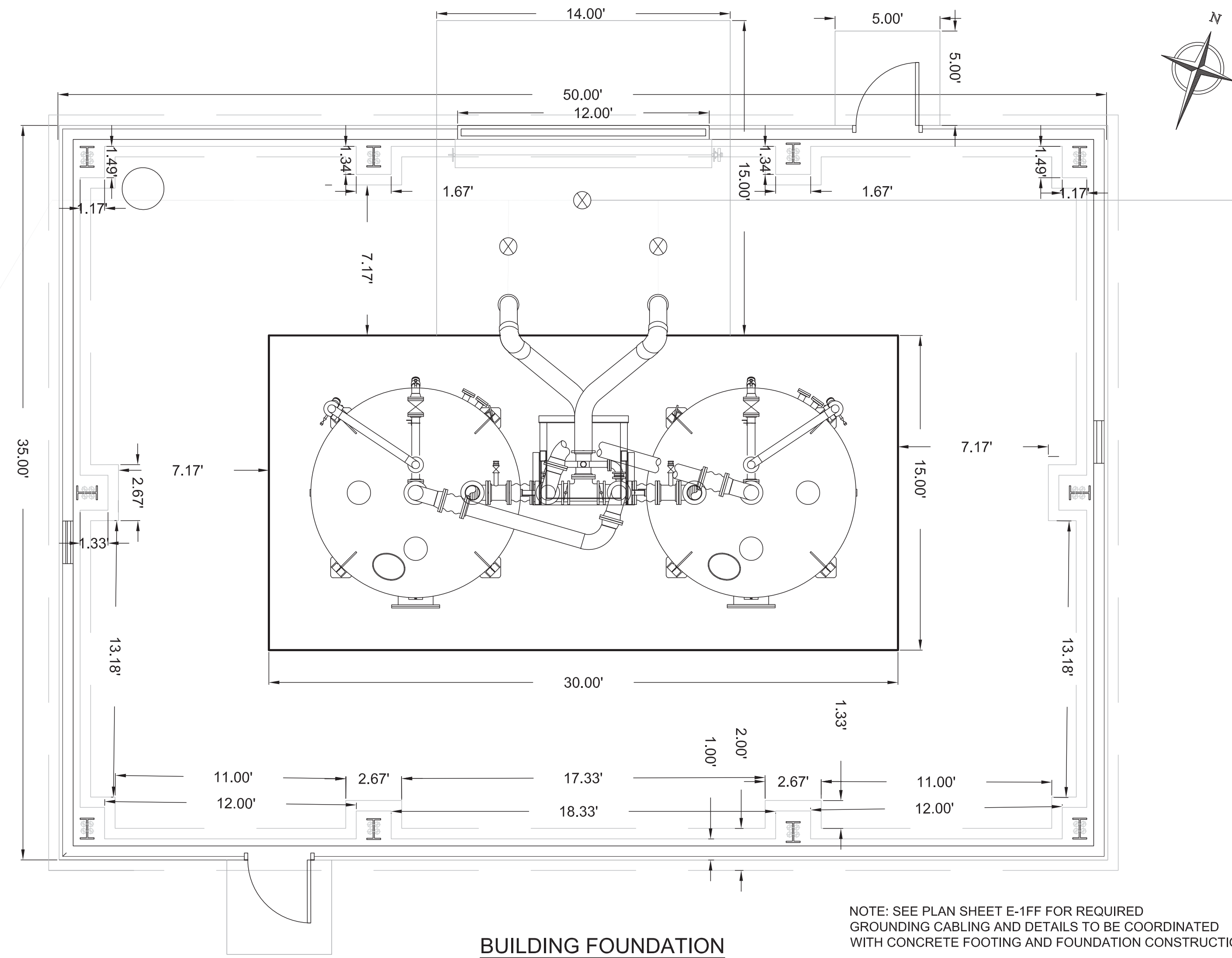
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: FORMER FIREHOUSE SITE PLAN DETAILS AT RAV BASIN	
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 20 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: S-5FF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH:			



BUILDING SECTION

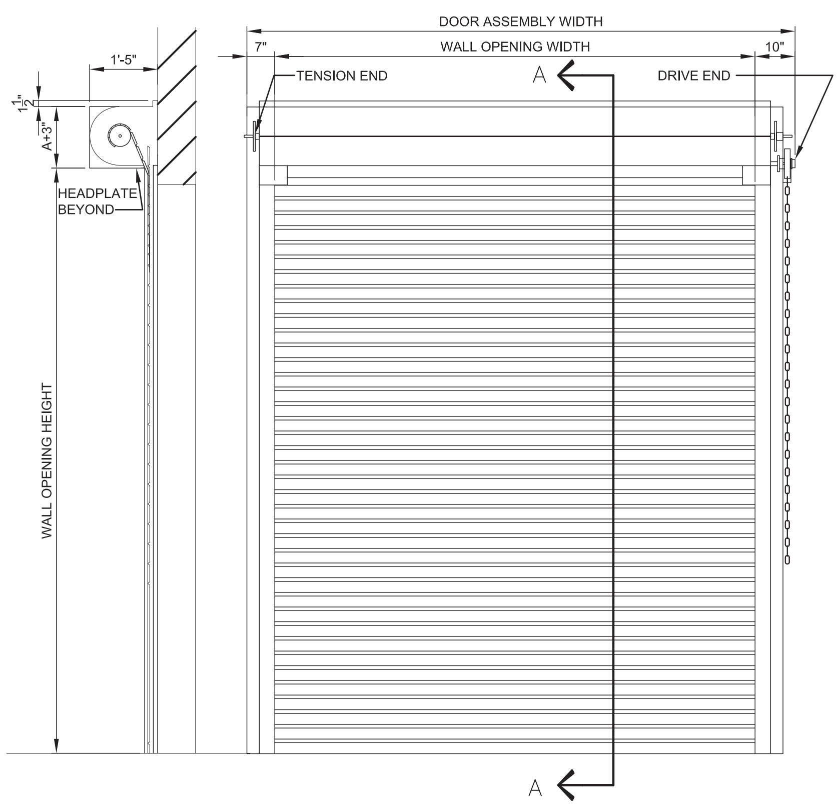
SCALE: 1/4" = 1'



NOTE: SEE PLAN SHEET E-1FF FOR REQUIRED GROUNDING CABLING AND DETAILS TO BE COORDINATED WITH CONCRETE FOOTING AND FOUNDATION CONSTRUCTION.

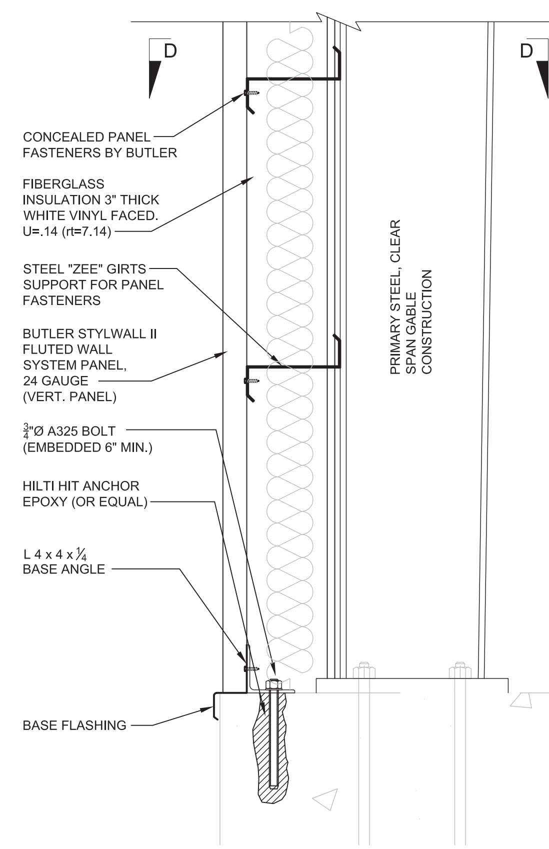
BUILDING FOUNDATION

SCALE: 1/4" = 1'



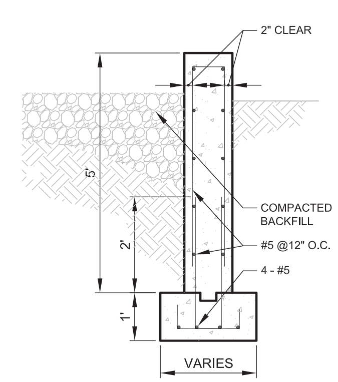
INSULATED WAYNE DALTON 12' x 10' ROLL UP DOOR DETAIL

SCALE: 1/2" = 1'



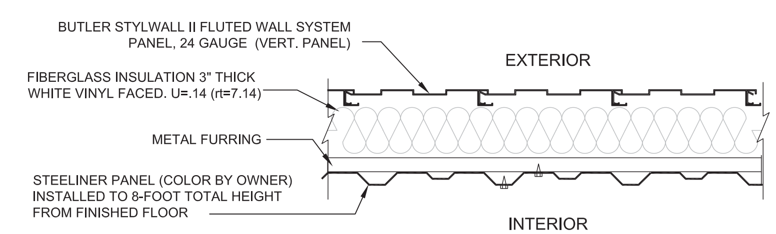
BUTLER STYLWALL II WALL SYSTEM PANEL

SCALE: 1" = 30'



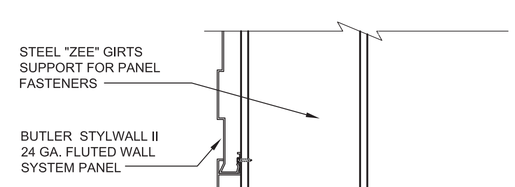
FOUNDATION DETAIL

SCALE: 1/2" = 1'



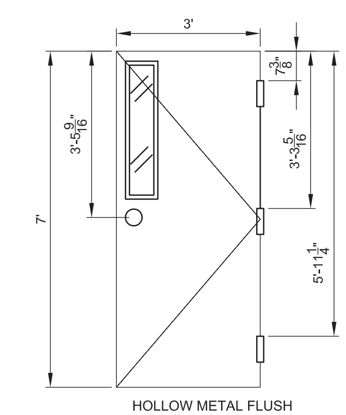
TYPICAL WALL SECTION WITH STEELINER PANEL

N.T.S.



D-D

SCALE: 1" = 30'



FIRE RATED DOOR DETAIL

SCALE: 1/2" = 1'

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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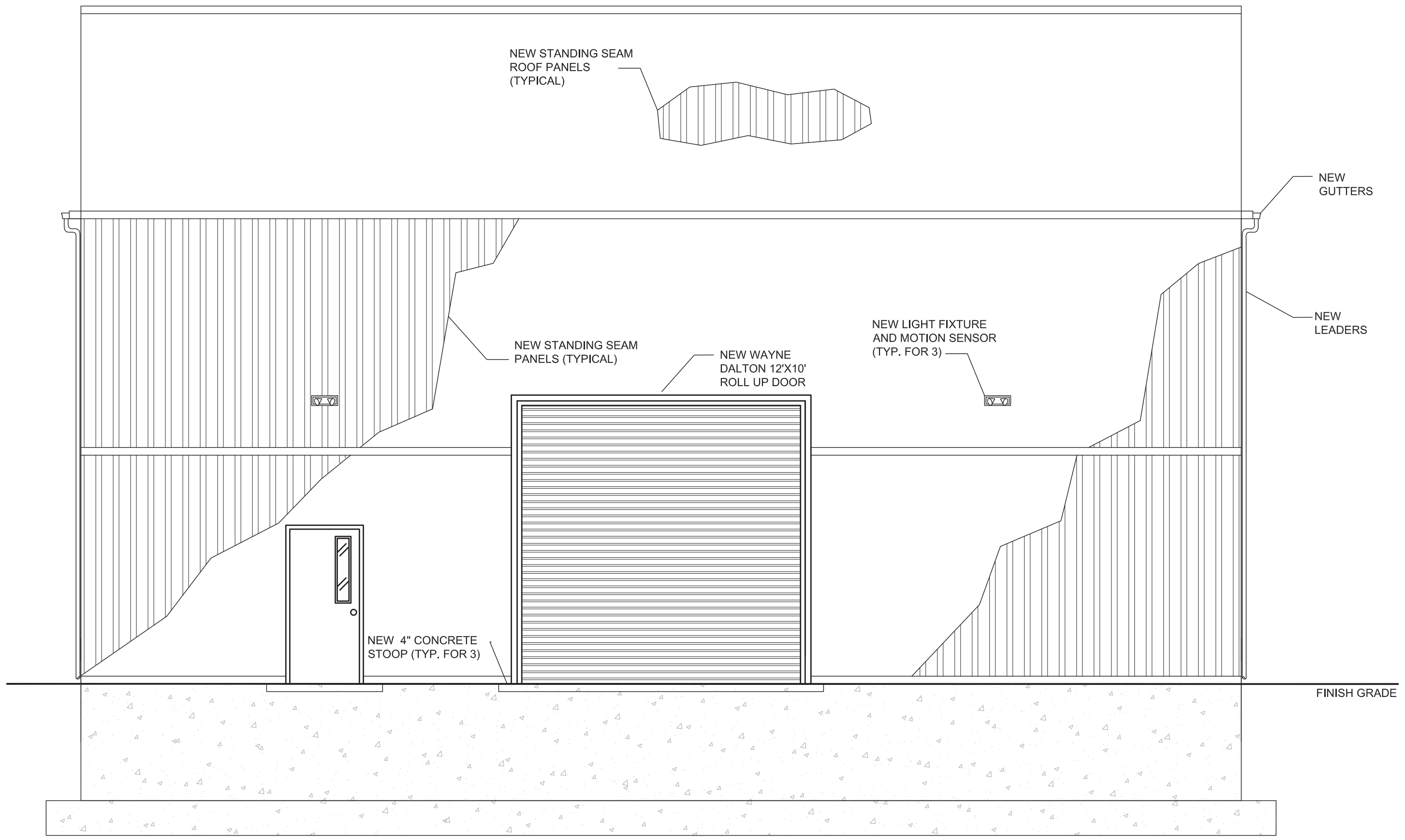
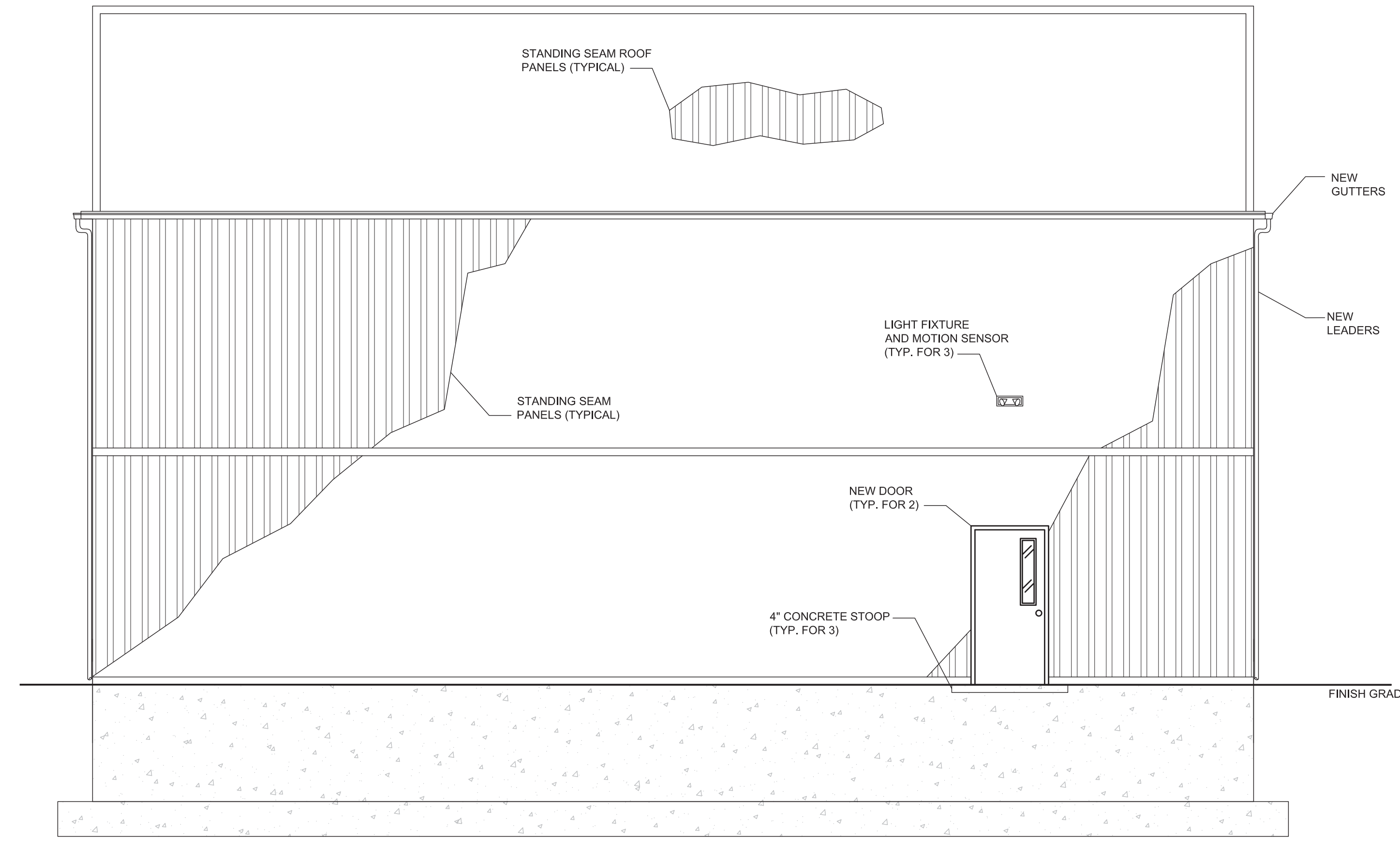
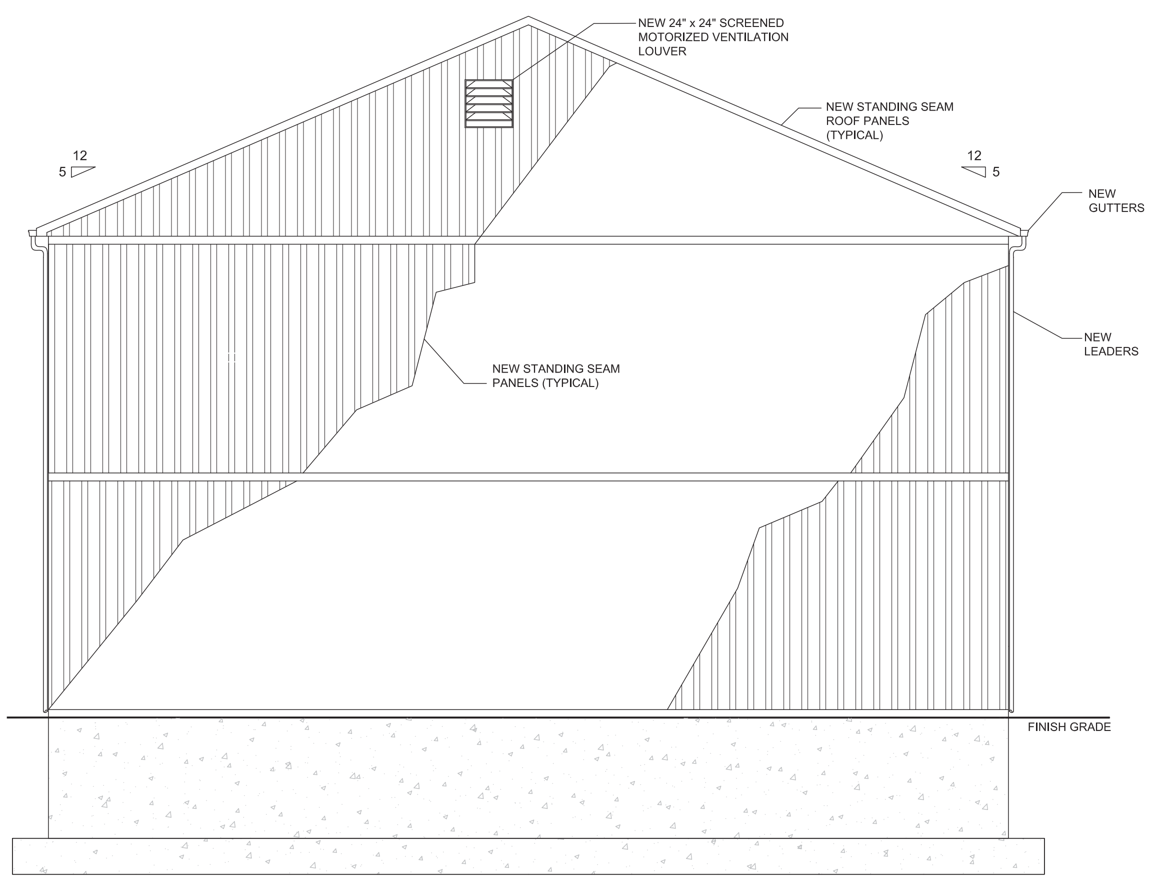
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: FORMER FIREHOUSE–NEW GAC BUILDING SECTION & DETAILS	
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 21 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: A–1FF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH:			



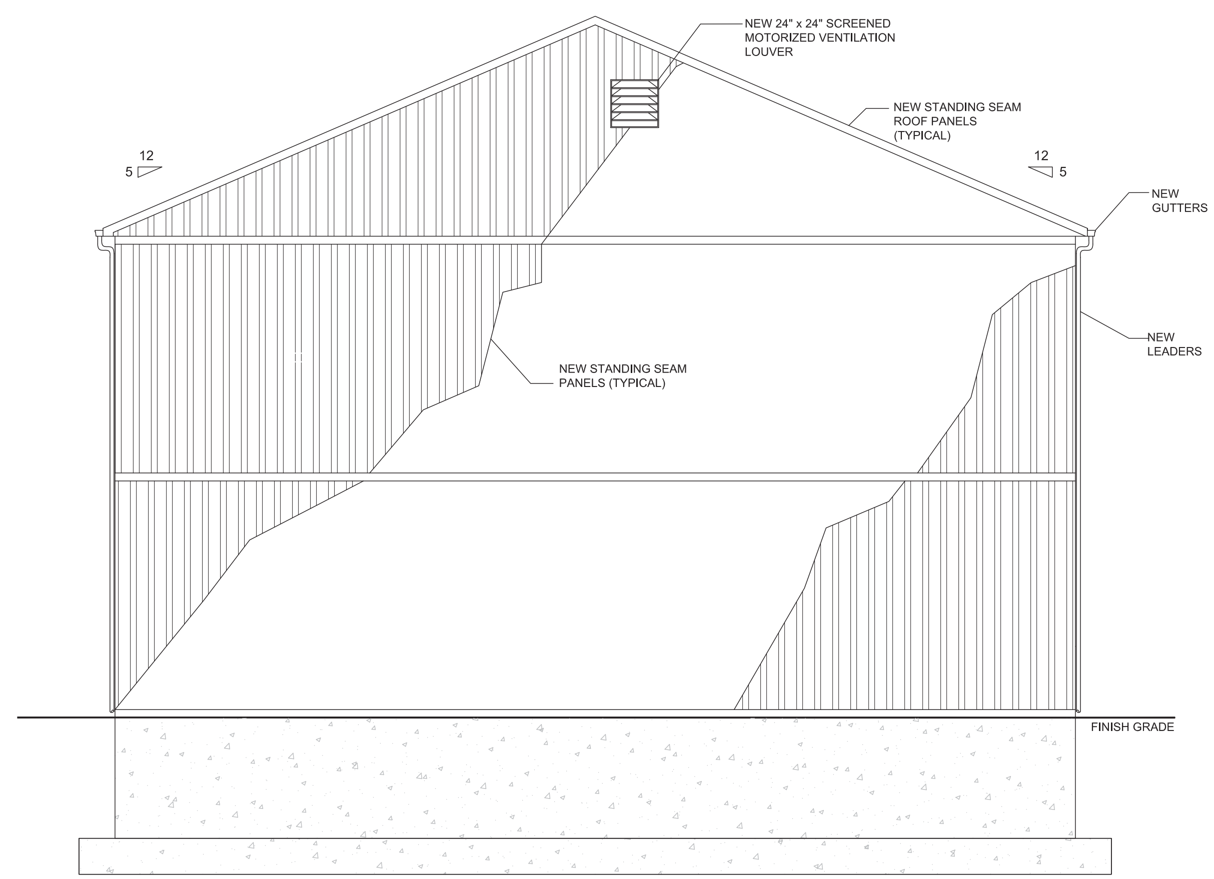
NORTH ELEVATION
SCALE: 1/4" = 1'-0"



SOUTH ELEVATION
SCALE: 1/4" = 1'-0"



EAST ELEVATION
SCALE: 1/4" = 1'-0"



WEST ELEVATION
SCALE: 1/4" = 1'-0"

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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PHONE: (631) 234-2220 FAX: (631) 234-2221 E-MAIL: info@holzmacher.com

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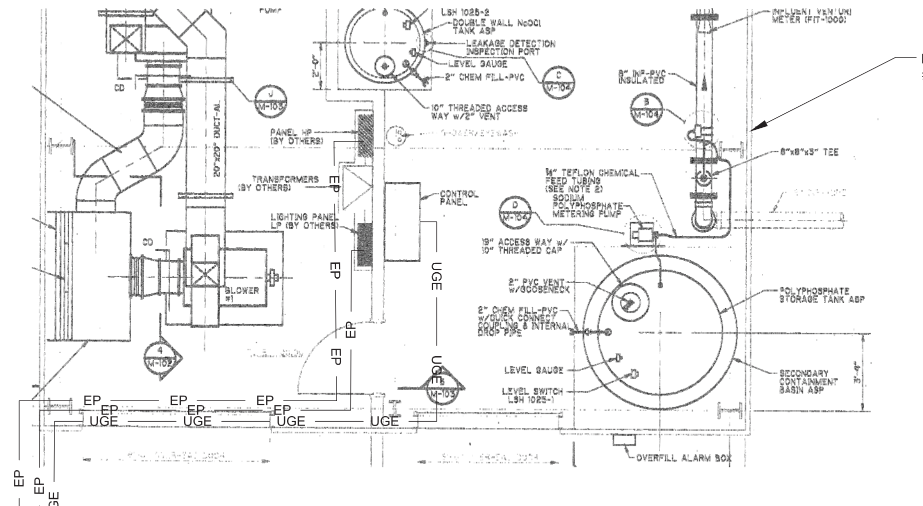
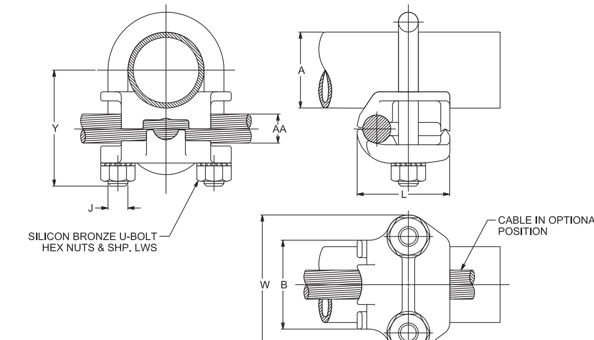
JOB TITLE		DWG. TITLE	
PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		FORMER FIREHOUSE–NEW GAC BUILDING ELEVATIONS	
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 22 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: A–2FF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH:			



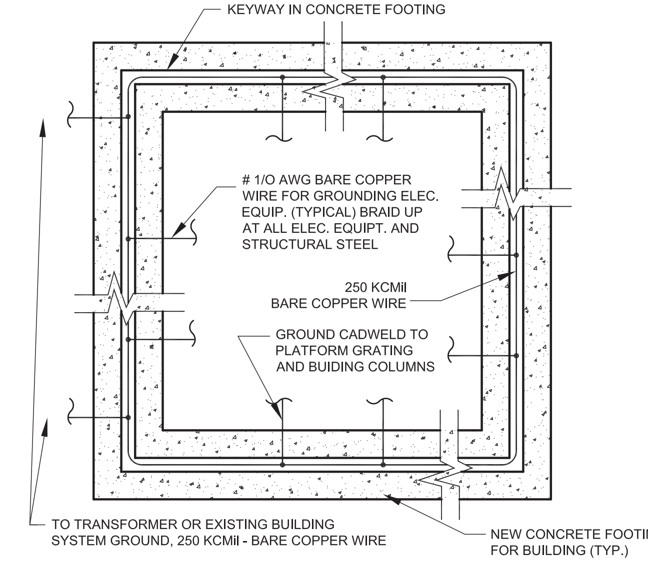
A			AA							
ROD ACCOMMODATED			COPPER CONDUCTOR ACCOMMODATED							
NOMINAL DIAMETER (in)	ACTUAL DIAMETER		AWG				METRIC WIRE SIZE			
			MIN		MAX		MIN		MAX	
	(in)	[mm]	SIZE	DIA	SIZE	DIA	SIZE	DIA	SIZE	DIA
0.5	0.500	[13]	2/0 sol	0.365	250 kcmil	0.575	70mmÉStr	[10.9]	120mmÉstr	[14.4]

B		Y		J		L		W		"U" BOLT	TORQUE	
(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)		Lb*in	N*m
1.75	[44]	1.88	[48]	3/8	[10]	1.81	[46]	1.88	[48]	271	240	27.0

NOTES:
MATERIAL: CAST COPPER ALLOY.
1. FINISH: BRIGHT DIPPED.
2. UL 467 LISTED FILE NO. E9999,
3. ACCEPTABLE FOR DIRECT BURIAL.
BURNDY CAT NO. GAR1129



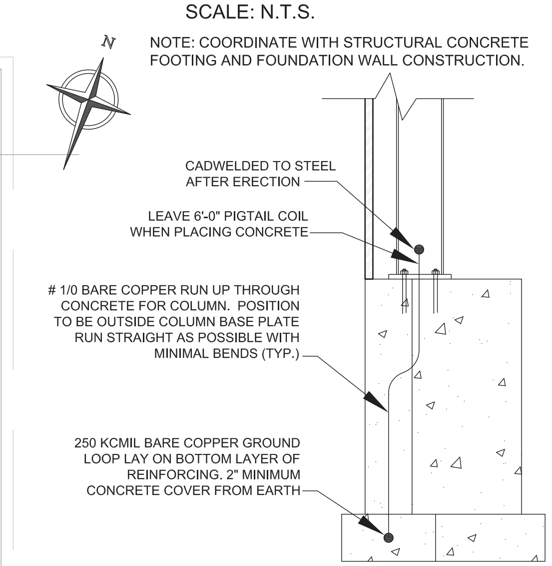
ELECTRICAL GROUNDING RODS CONNECTION DETAIL
N.T.S.



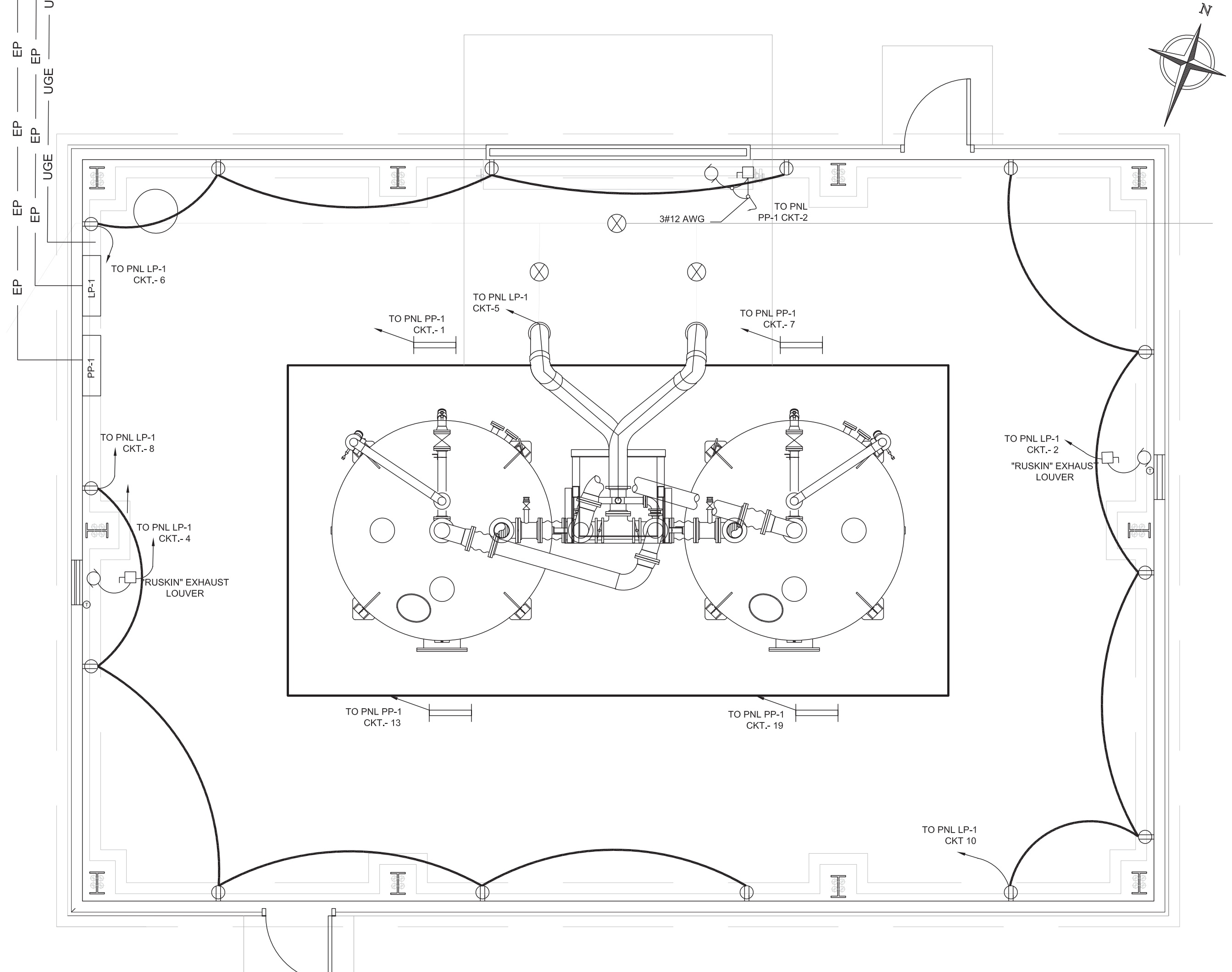
NOTE: TYPICAL FOR ALL SLABS AND FOOTINGS

BUILDING GROUNDING DIAGRAM
SCALE: N.T.S.

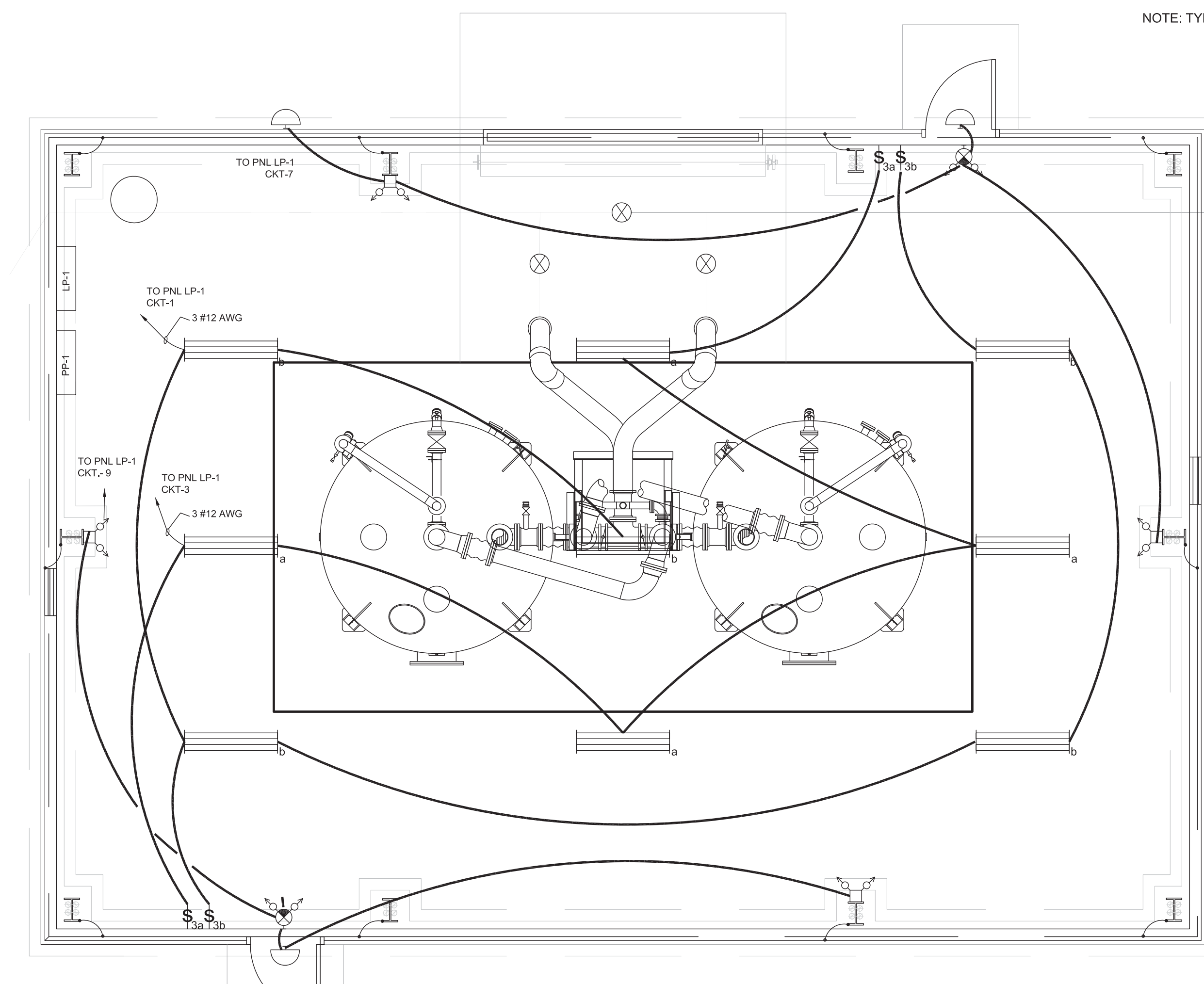
NOTE: COORDINATE WITH STRUCTURAL CONCRETE FOOTING AND FOUNDATION WALL CONSTRUCTION.



TYPICAL GROUNDING CONNECTION TO COLUMN
N.T.S.



ELECTRICAL POWER PLAN
SCALE: 1/4" = 1'



ELECTRICAL LIGHTING & GROUND PLAN
SCALE: 1/4" = 1'

POWER LEGEND

MOTOR / EQUIPMENT

WALL MOUNTED RECEPTACLE, 120V, 20A, SINGLE PHASE, MOUNTING HEIGHT 2'-0" AFF, WP - WEATHER PROOF

THERMOSTAT

LOUVERS SHALL BE "RUSKIN" MODEL EME520DD, OR APPROVED EQUAL

NEW ELECTRIC INFRARED HEATER, 4300W, SUSPENDED MOUNTING TYPE, 480V AC, 3-PHASE, FOSTORIA FSS-4348-3 OR APPROVED EQUAL

NOTE: EXISTING HEAT TRACE TO BE REMOVED AND REPLACED WITH APPROVED EQUAL

LIGHTING LEGEND

LITHONIA LIGHTING, MODEL DMW2 L24 2000LM MD PCL MVOLT GZ1 40K 80CRI OR APPROVED EQUAL

LED FLOODLIGHTS WITH MOTION SENSOR, 2 ADJUSTABLE HEADS MOUNTING HEIGHT 12'-0" ABOVE GRADE, WITH PHOTO CELL. LITHONIA LIGHTING, MODEL OFLR 6LC 120 MO WH OR APPROVED EQUAL.

$ $ 3a 3b — WALL-MOUNTED 3-WAY SWITCH

LED LAMPS IN EXIT HOUSING, SINGLE FACE, WITH RED LETTERS AND WHITE HOUSING BATTERY POWER BACK UP, MOUNTING HEIGHT 7'-6" AFF LITHONIA LIGHTING, MODEL LQM S W 3 R 120/277 OR APPROVED EQUAL.

WALL MOUNT LED, 2 HEAD, WET LOCATION.BATTERY POWER BACK UP ,MOUNTING HEIGHT 7'-6" AFF LITHONIA LIGHTING, MODEL WLTU MR GY OR APPROVED EQUAL.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS – 1 OF 5	
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 23 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: E-1FF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH:			

PANELBOARD NO: ***B-598-PP-1***

SECTION: 1 OF 1	**VOLTAGE:** 480Y/277V	**BUS:** 100 A	
MOUNTING: SURFACE	**PHASE:** 3	**MAIN:** MCB	
	WIRE: 3	**INTERRUPTING RATING:** 522 KAIC	
LOCATION: BLDG	**NEUTRAL:** ##	**ELECTRONIC GRADE PANEL:** NO	
		SUBMETER: NO	

CKT	DESCRIPTION	LOAD (KVA)						CIRCUIT BREAKER					CIRCUIT BREAKER		LOAD (KVA)						DESCRIPTION	CKT
NO.		LTS	REC	EQPT	MECH	ELEV	MISC	AMPS	POLES				AMPS	POLES	LTS	REC	EQPT	MECH	ELEV	MISC		NO
1	EUH-1			5.8				20		A			20								OH DOOR-1	2
3	"			5.8							B										"	4
5	"			5.8					3			C		3							"	6
7	EUH-2			5.8				20		A			50				6.7				30 kVA Xfmr	8
9	"			5.8							B						4.7				"	10
11	"			5.8					3			C		3			8.2				"	12
13	EUH-3			5.8				20		A			20								SPARE	14
15	"			5.8							B											16
17	"			5.8					3			C		3								18
19	EUH-4			5.8				20		A			50								SPARE	20
21	"			5.8							B											22
23	"			5.8					3			C		3								24
25	SPARE							-	1	A			-	1							SPARE	26
27	SPARE							-	1		B		-	1							SPARE	28
29	SPACE							-	1			C	-	1							SPACE	30
31								-		A			-									32
33								-			B		-									34
35								-				C	-									36
37								-		A			-									38
39								-			B		-									40
41								-				C	-									42

PHASE BALANCE

	LTS	REC	EQPT	MECH	ELEV	MISC	TOTAL	% DIF
PHASE A CONNECTED KVA	0.0	0.0	29.9	0.0	0.0	0.0	29.9	0.6
PHASE B CONNECTED KVA	0.0	0.0	27.9	0.0	0.0	0.0	27.9	-6.2
PHASE C CONNECTED KVA	0.0	0.0	31.4	0.0	0.0	0.0	31.4	5.6
						AVERAGE PHASE CONNECTED KVA	29.7	

LOAD SUMMARY

LTS	REC	EQPT	MECH	ELEV	MISC	SUBTOT	SPARE	TOTAL	
0	0	89	0	0	0	89	25		CONNECTED KVA
									25% OF THE LARGEST MOTOR
	NOTE 1	NOTE 2		NOTE 3	NOTE 4				DEMAND FACTOR
1.25	1.00	1.00	1.00	1.00	1.00				CONTINUOUS / NON-CONTINUOUS
0	0	89	0	0	0	89	22	112	DESIGN KVA
NOTE 1 - PER NEC 220.44 (100% OF1ST 10 + 50% OF REMAINING)								480	PHASE VOLTAGE
NOTE 2 -								134	DESIGN AMPS
NOTE 3 - PER NEC 620.14									
NOTE 4 -									

PANELBOARD NO: ***B-598 LP-1***

SECTION: 1 OF 1	**VOLTAGE:** 208Y/120	**BUS:** 225 A	
MOUNTING: SURFACE	**PHASE:** 3	**MAIN:** MLO	
	WIRE: 4	**INTERRUPTING RATING:** 10 KAIC	
LOCATION: BLDG	**NEUTRAL:** 100%	**ELECTRONIC GRADE PANEL:** NO	
		SUBMETER: YES	

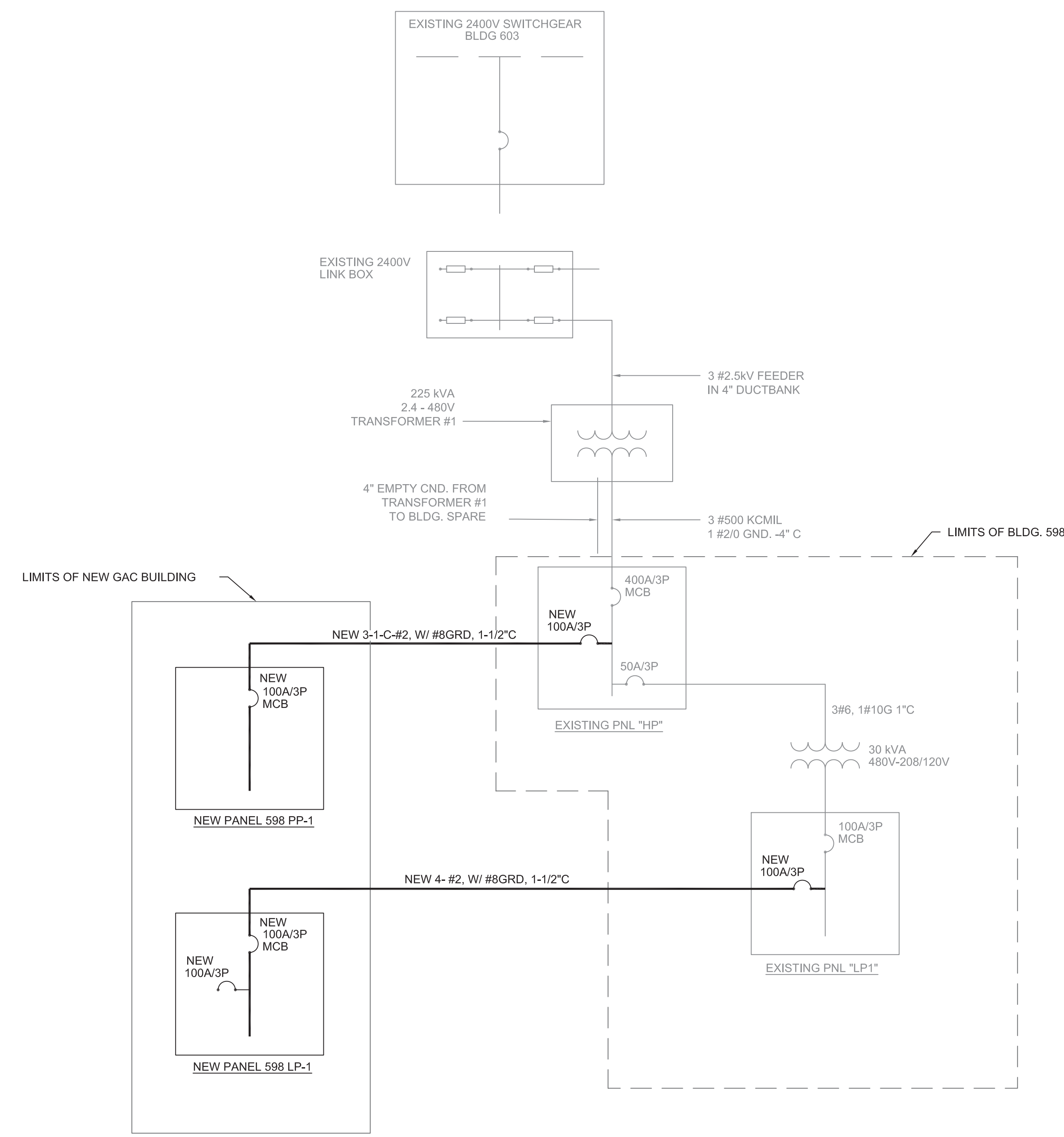
CKT	DESCRIPTION	LOAD (KVA)						CIRCUIT BREAKER					CIRCUIT BREAKER		LOAD (KVA)						DESCRIPTION	CKT
NO.		LTS	REC	EQPT	MECH	ELEV	MISC	AMPS	POLES				AMPS	POLES	LTS	REC	EQPT	MECH	ELEV	MISC		NO
1	LIGHTING (Interior)	0.7						20	1	A			20	1				3.0			EXHAUST FANS 1	2
3	LIGHTING (Interior)	0.7						20	1		B		20	1				3.0			EXHAUST FANS 2	4
5	SPARE							20	1			C	20	1		0.9					RECEPTACLE	6
7	LIGHTING (emergency)	0.1						20	1	A			20	1		0.9					RECEPTACLE	8
9	LIGHTING (emergency)	0.1						20	1		B		20	1		0.9					RECEPTACLE	10
11	SPARE							20	1			C	20	1							"	12
13	SPARE							20	1	A			20	1							SPARE	14
15	SPARE							20	1		B		20	1							SPARE	16
17	SPARE							20	1			C	20	1							SPARE	18
19	SPARE							20	1	A			20	1							SPARE	20
21	SPARE							20	1		B		20	1							SPARE	22
23	SPARE							20	1			C	20	1							SPARE	24
25	SPACE							-	1	A			-	1							SPACE	26
27	SPACE							-	1		B		-	1							SPACE	28
29	SPACE							-	1			C	-	1							SPACE	30
31	SPACE							-	1	A			-	1							SPACE	32
33	SPACE							-	1		B		-	1							SPACE	34
35	SPACE							-	1			C	-	1							SPACE	36
37	SPACE							-	1	A			-	1							SPACE	38
39	SPACE							-	1		B		-	1							SPACE	40
41	SPACE							-	1			C	-	1							SPACE	42

PHASE BALANCE

	LTS	REC	EQPT	MECH	ELEV	MISC	TOTAL	% DIF
PHASE A CONNECTED KVA	0.8	0.9	0.0	3.0	0.0	0.0	4.7	36.9
PHASE B CONNECTED KVA	0.8	0.9	0.0	3.0	0.0	0.0	4.7	36.9
PHASE C CONNECTED KVA	0.0	0.9	0.0	0.0	0.0	0.0	0.9	-73.8
						AVERAGE PHASE CONNECTED KVA	3.4	

LOAD SUMMARY

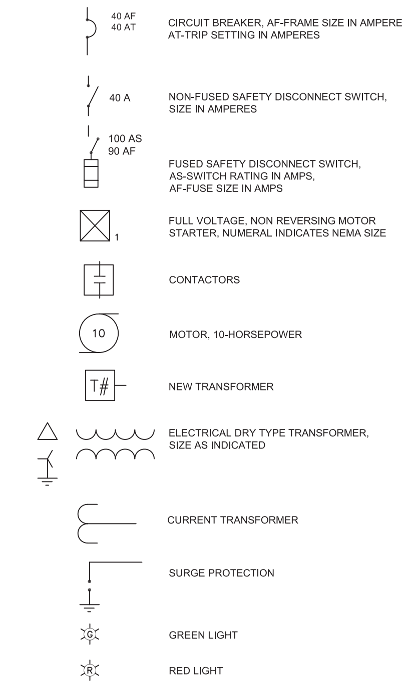
LTS	REC	EQPT	MECH	ELEV	MISC	SUBTOT	SPARE	TOTAL	
2	3	0	6	0	0	10	25		CONNECTED KVA
									25% OF THE LARGEST MOTOR
	NOTE 1	NOTE 2		NOTE 3	NOTE 4				DEMAND FACTOR
1.25	1.00	1.00	1.00	1.00	1.00				CONTINUOUS / NON-CONTINUOUS
2	3	0	6	0	0	11	3	13	DESIGN KVA
NOTE 1 - PER NEC 220.44 (100% OF1ST 10 + 50% OF REMAINING)								208	PHASE VOLTAGE
NOTE 2 -								37	DESIGN AMPS
NOTE 3 - PER NEC 620.14									
NOTE 4 -									



SINGLE LINE DIAGRAM - BUILDING 598

N.T.S.

LEGEND



FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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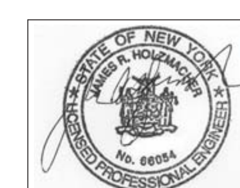

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PHONE: (631) 234-2220 FAX: (631) 234-2221 E-MAIL: info@holzmacher.com

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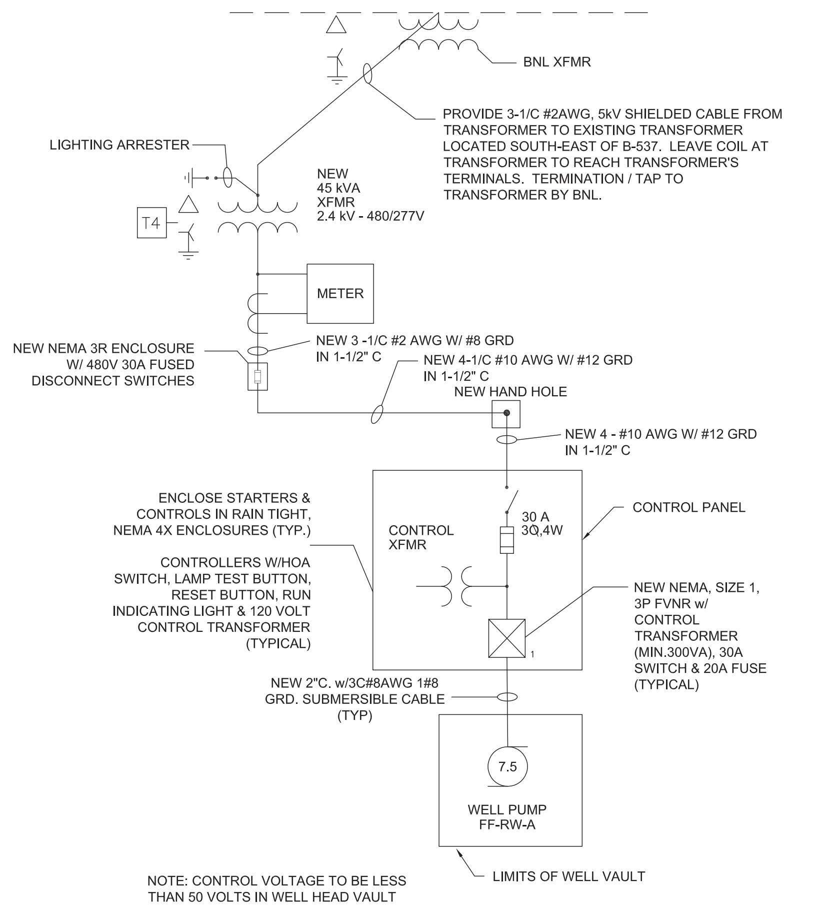
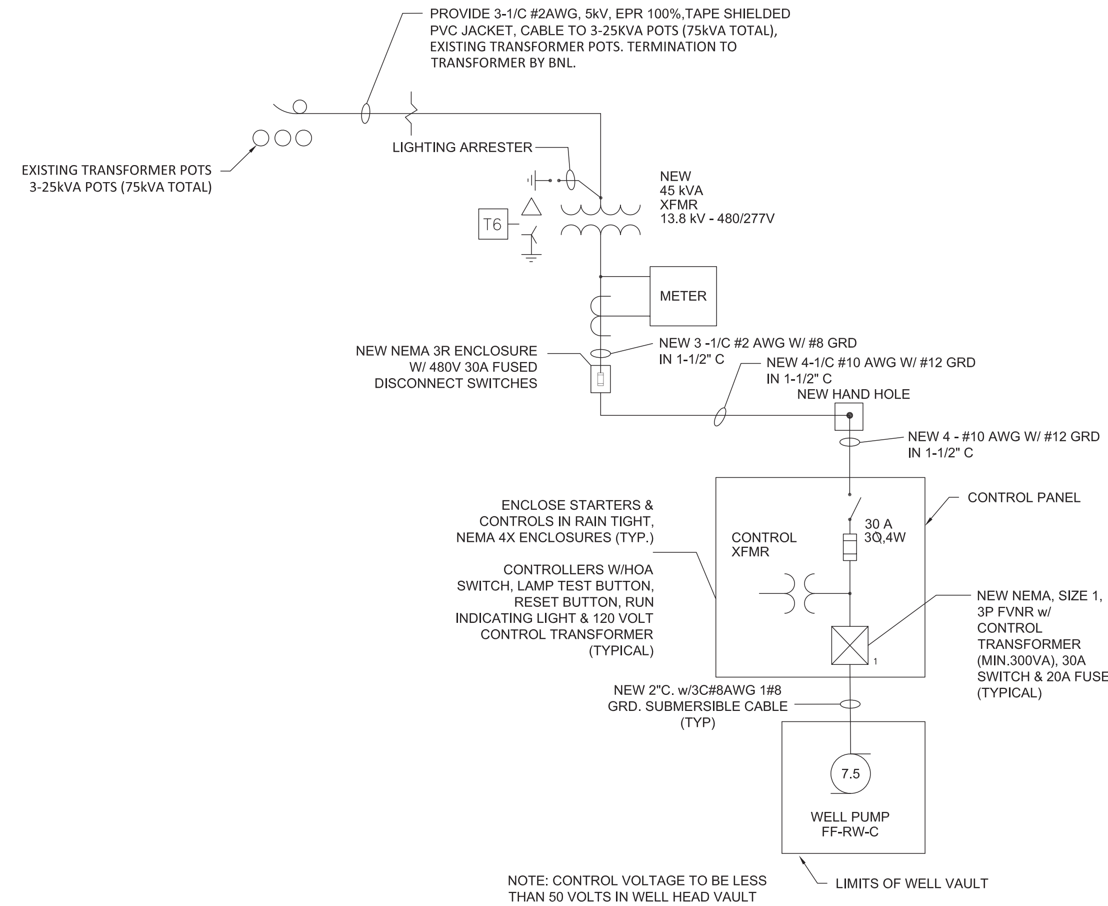
JOB TITLE PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS – 2 OF 5	
ILR,GPP,LNI, HEM –	DATE 4/1/2021	ACCT. NO. 21097	SHEET 24 OF 33
SCALE AS SHOWN	DWN. BY AJZ	JOB NO. 14011	DWG. NO. E–2FF
PROJ. QA A3–MINOR	APP'D. BY JRH	BLDG. NO. –	
PATH:			



SINGLE LINE POWER DIAGRAM - FFH 1

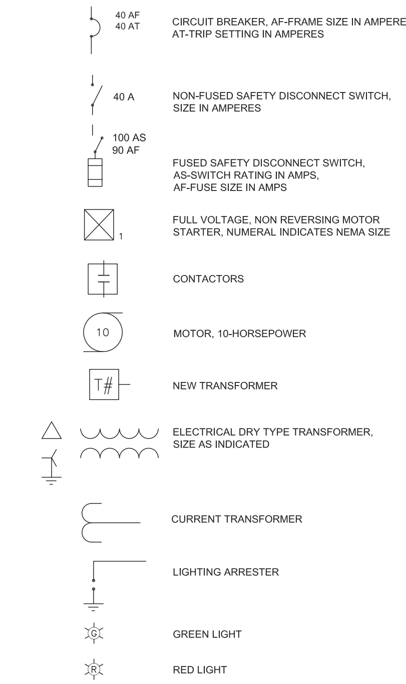
N.T.S.

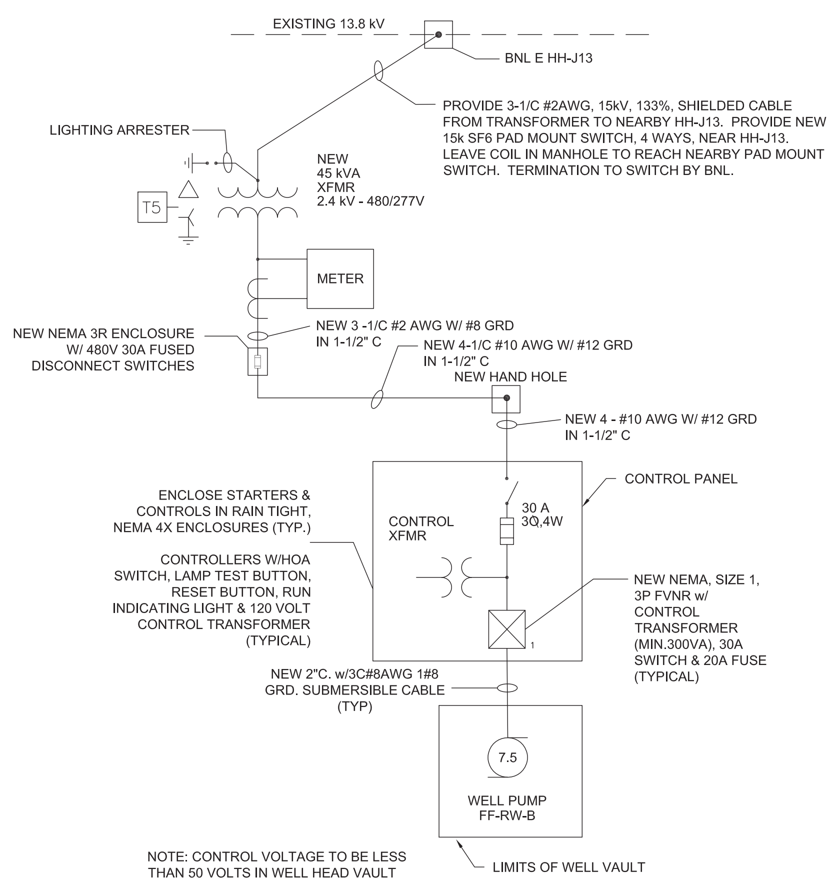


SINGLE LINE POWER DIAGRAM - FFH 3

N.T.S.

LEGEND





SINGLE LINE POWER DIAGRAM - FFH 2

N.T.S.

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JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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JOB TITLE PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS – 3 OF 5	
ILR,GPP,LNI, HEM –	DATE 4/1/2021	ACCT. NO. 21097	SHEET 25 OF 33
SCALE AS SHOWN	DWN. BY AJZ	JOB NO. 14011	DWG. NO. E–3FF
PROJ. QA A3–MINOR	APP'D. BY JRH	BLDG. NO. –	
PATH:			

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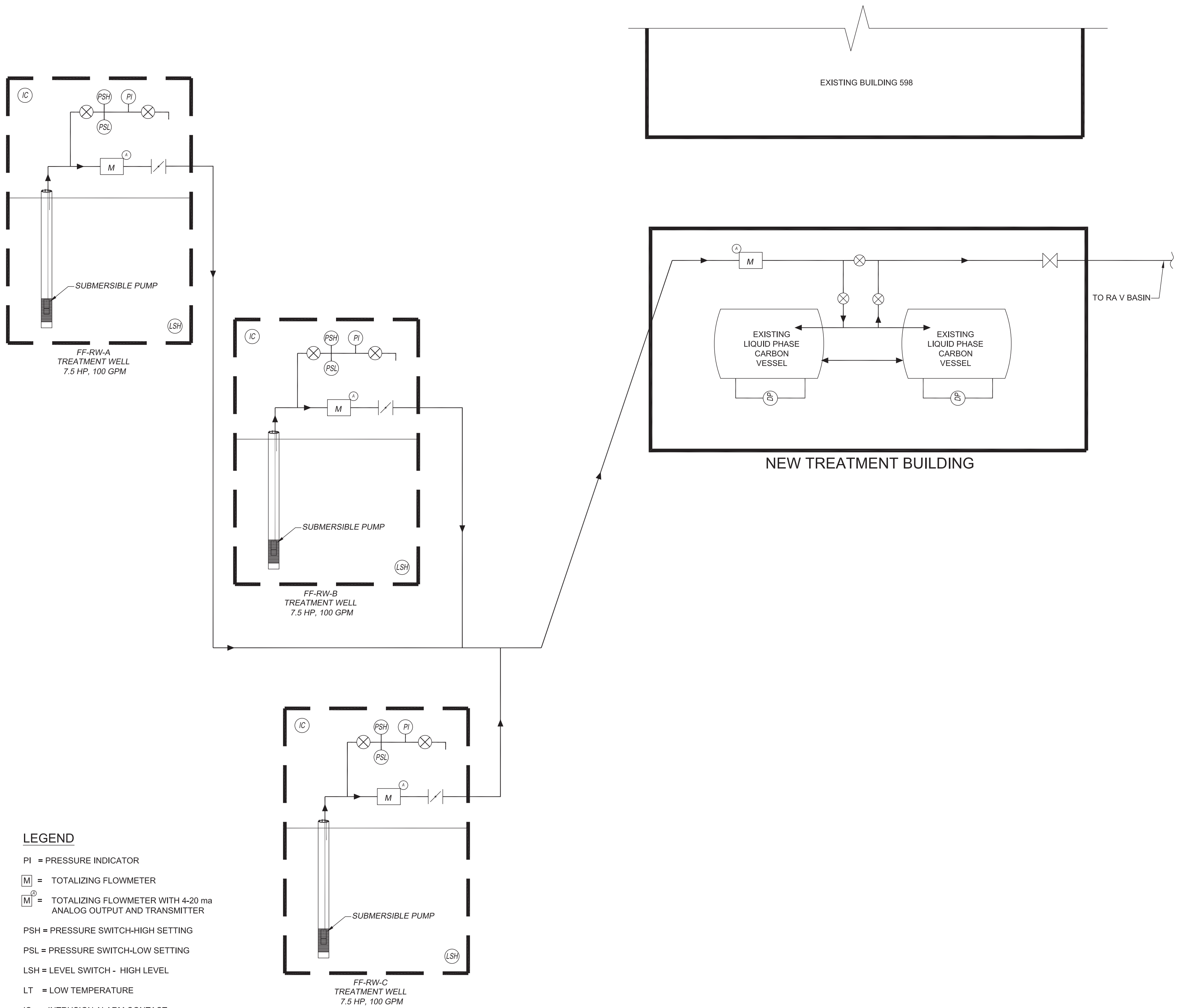

LEGEND

- PI = PRESSURE INDICATOR
- M = TOTALIZING FLOWMETER
- M = TOTALIZING FLOWMETER WITH 4-20 ma ANALOG OUTPUT AND TRANSMITTER
- PSH = PRESSURE SWITCH-HIGH SETTING
- PSL = PRESSURE SWITCH-LOW SETTING
- LSH = LEVEL SWITCH - HIGH LEVEL
- LT = LOW TEMPERATURE
- IC = INTRUSION ALARM CONTACT
- FS = FIRE / SMOKE DETECTORS
- DP = DIFFERENTIAL PRESSURE SWITCH
- ASV = ANTI-SYPHON VALVE
- = SAMPLE PORT

PROCESS AND INSTRUMENTATION DIAGRAM - FFH

N.T.S.

NOTE: SEE PLAN SHEETS 31-CC-1 AND 32-CC-2 FOR COMMUNICATION AND CONTROLS DETAILS

FINAL DESIGN

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STATE OF NEW YORK · JAMES R. HOLZMACHER · No. 66054 · LICENSED PROFESSIONAL ENGINEER

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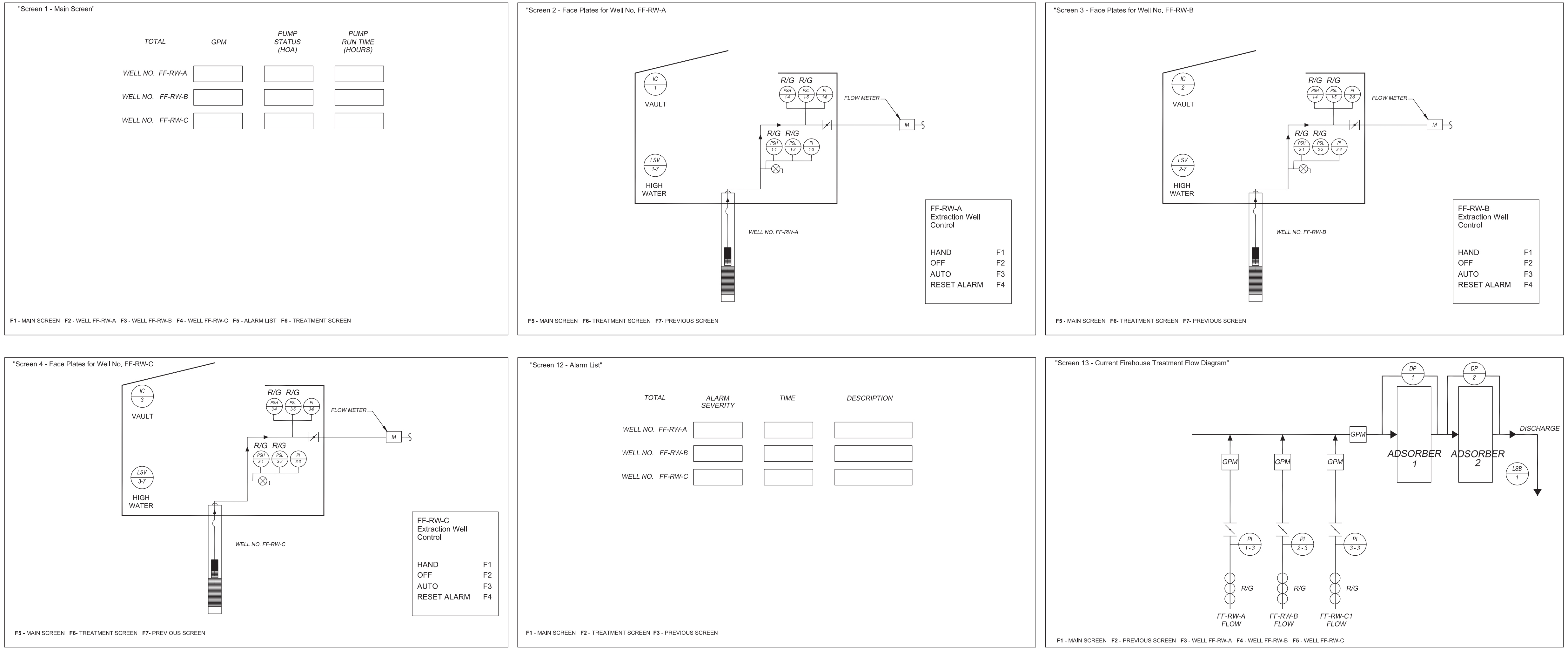
ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 26 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: E-4FF
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH:			



LEGEND

PI = PRESSURE INDICATOR

PSH = PRESSURE SWITCH - ALARM ON HIGH

PSL = PRESSURE SWITCH - ALARM ON LOW

LSH = LEVEL SWITCH - ALARM ON HIGH WATER LEVEL IN CASING

LSB = LEVEL SWITCH - ALARM ON HIGH WATER LEVEL IN BUILDING

LSV = LEVEL SWITCH - ALRM ON HIGH WATER LEVEL IN WELL VAULT

DP = DIFFERENTIAL PRESSURE SWITCH - ALARM ON HIGH

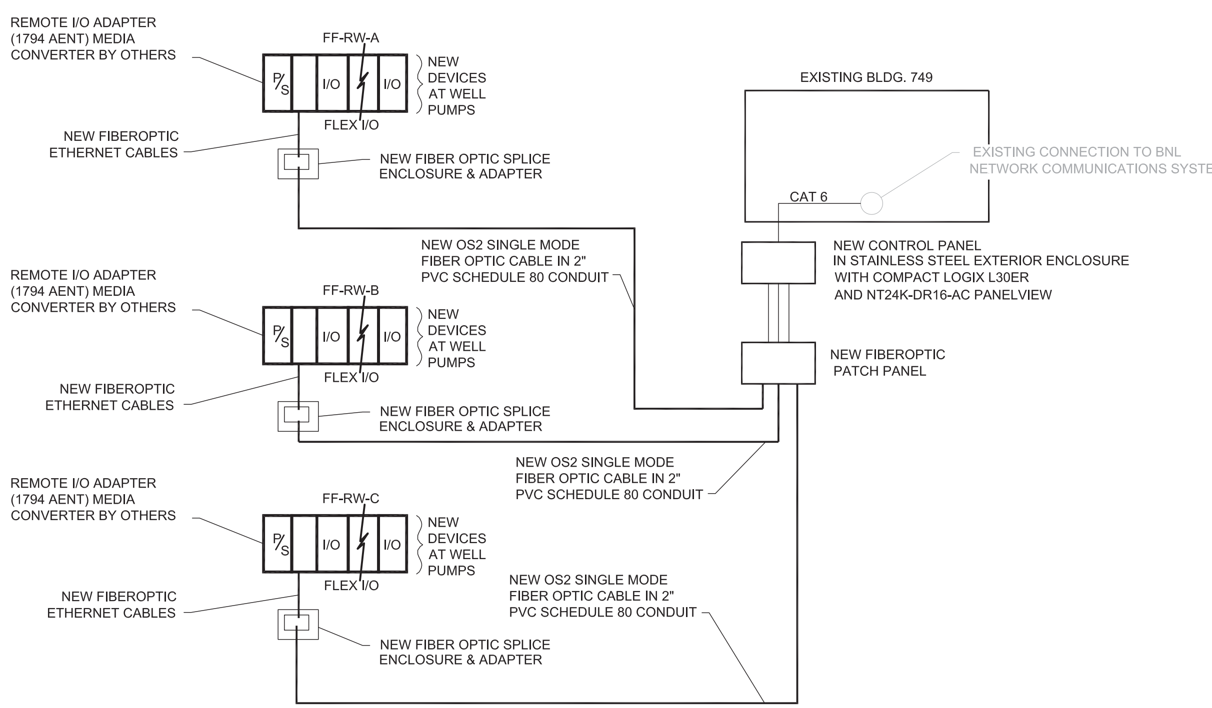
LT = LOW TEMP SENSOR

R/G = GRAPHIC OBJECT SHALL BE COLOR CODED
RED = OFF OR DOOR OPEN OR HIGH WATER, OR OUT OF RANGE
GREEN = ENERGIZED OR DOOR CLOSED OR LOW WATER
OR NORMAL RANGE

IC = INTRUSION CONTACT

PANELVIEW SCREEN LAYOUT - FFH

N.T.S.



COMMUNICATIONS BLOCK DIAGRAM - FFH

N.T.S.

NOTE: SEE PLAN SHEETS 31-CC-1 AND 32-CC-2 FOR COMMUNICATION AND CONTROLS DETAILS

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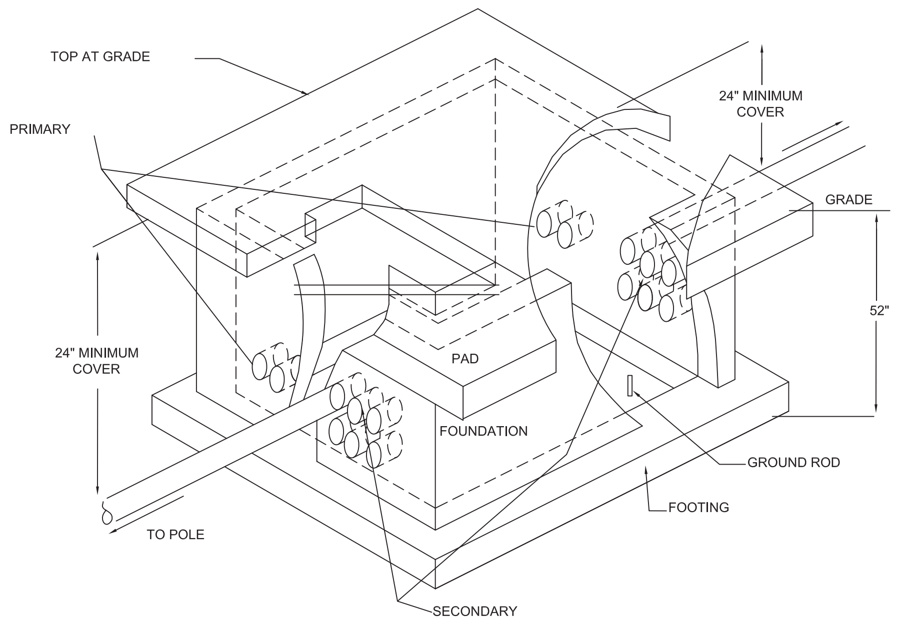
STATE OF NEW YORK JAMES R. HOLZMACHER No. 66054 LICENSED PROFESSIONAL ENGINEER

JOB TITLE PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE FORMER FIREHOUSE ELECTRICAL AND CONTROLS DETAILS – 5 OF 5	
ILR,GPP,LNI, HEM –	DATE 4/1/2021	ACCT. NO. 21097	SHEET 27 OF 33
SCALE AS SHOWN	DWN. BY AJZ	JOB NO. 14011	DWG. NO. E–5FF
PROJ. QA A3–MINOR	APP'D. BY JRH	BLDG. NO. –	
PATH:			



PREPARATION OF SUB-GRADE FOR FOOTING AND FOUNDATION.

A. REMOVE 52" OF SOIL TO REACH UNDISTURBED EARTH.

B. INSTALL PRECAST FOOTING AND FOUNDATION.

C. INSTALL CONDUITS AND GROUT ENTRANCES.

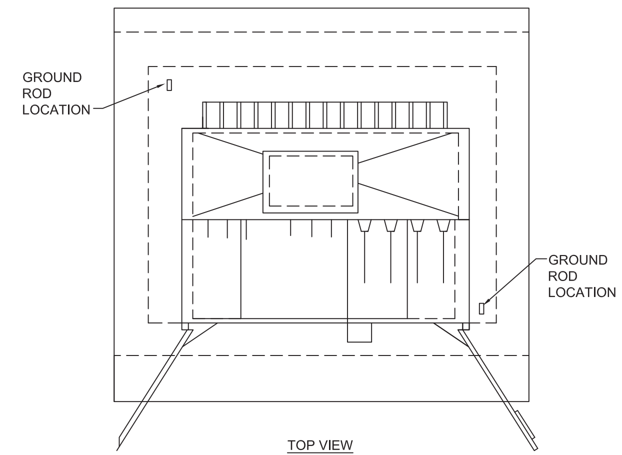
D. INSTALL PLUGS OR CAPS ON ALL UNUSED DUCT ENTRANCES.

E. BACKFILL OUTSIDE FOUDATION WITH CLEAN FILL, MECHANICALLY COMPACTED EVERY 12". DO NOT BACKFILL INSIDE FOUNDATION.

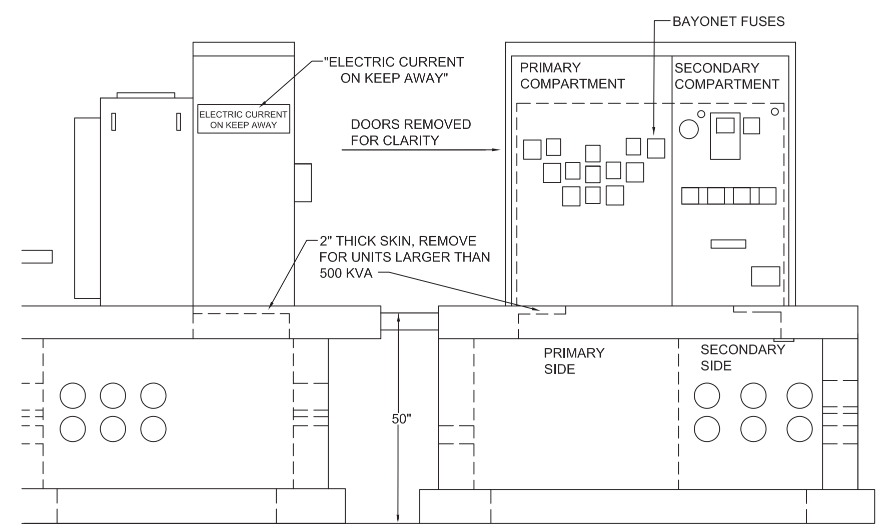
F. INSTALL 2 - 5/8" X 10' COPPERWELD GROUNDRODS DRIVEN FLUSH WITH TOP OF FOOTING (6 FEET APART).

TRANSFORMER INSTALLATION ISOMETRIC VIEW OF FOOTING: FOUNDATION AND PAD TOP

N.T.S



TOP VIEW

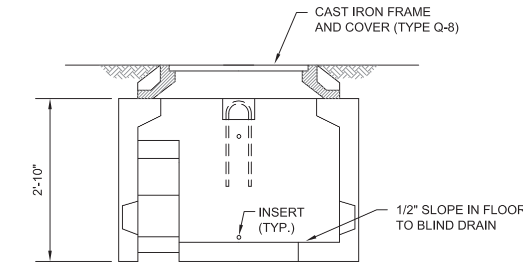


SIDE VIEW

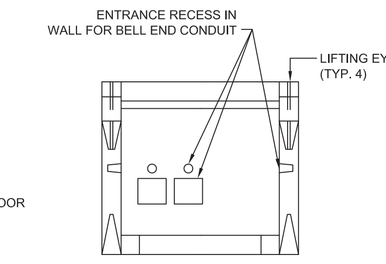
FRONT VIEW

TRANSFORMER INSTALLATION AND HOUSING CONSTRUCTION

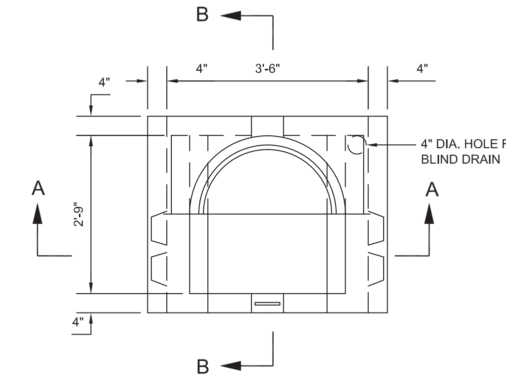
N.T.S.



SECTION A-A



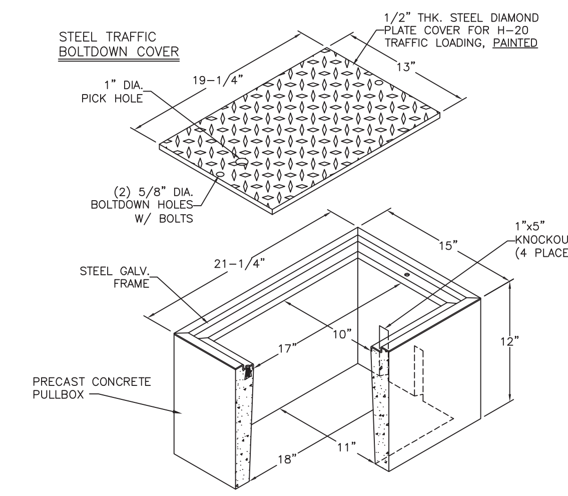
SECTION B-B



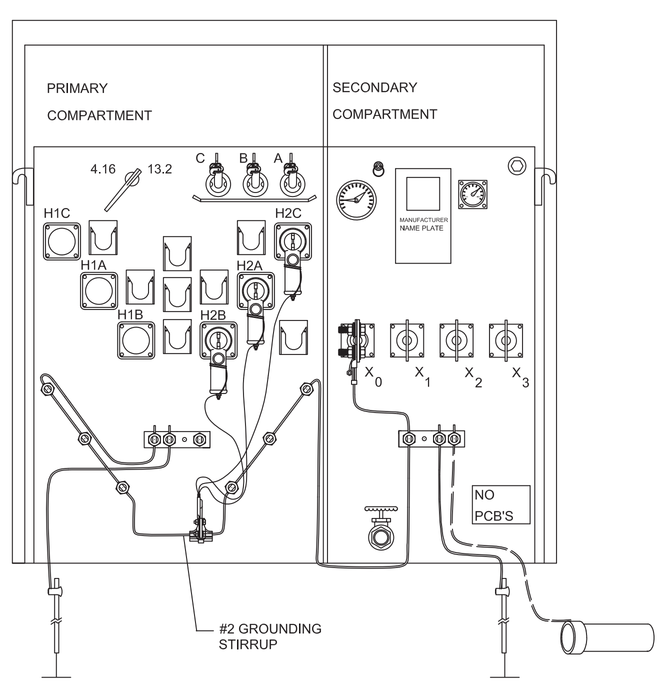
PLAN

ELECTRICAL HAND HOLE DETAIL

N.T.S.



SECONDARY SPLICE BOX (CONTROL WIRING)



FRONT ELEVATION WITH DOORS OPEN

TRANSFORMER GROUNDING DETAILS

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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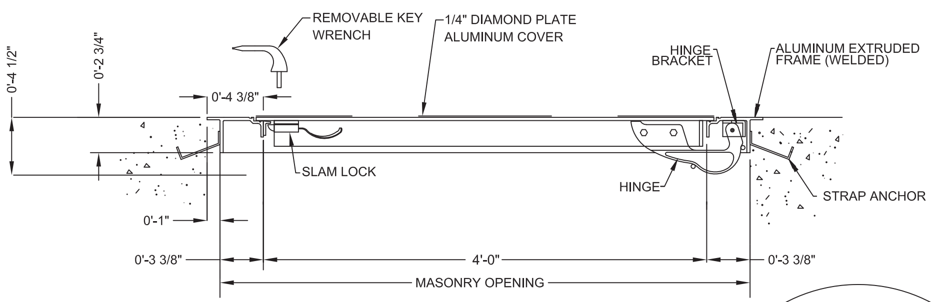
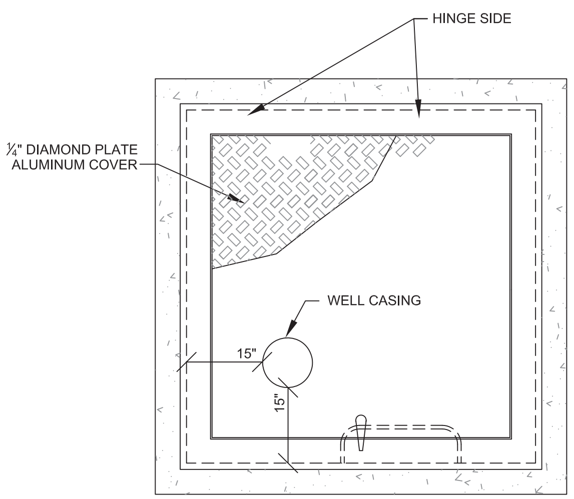
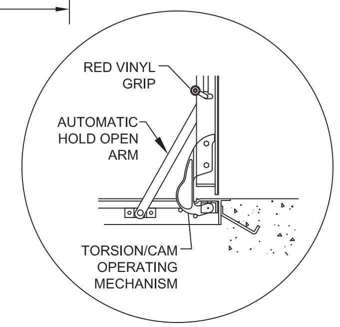
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: ELECTRICAL DETAILS 1 OF 1	
ILR,GPP,LNI, HEW: -	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 28 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: E-6
PROJ. QA: A3-MINOR	APP'D. BY: JRH	BLDG. NO.: -	
PATH:			



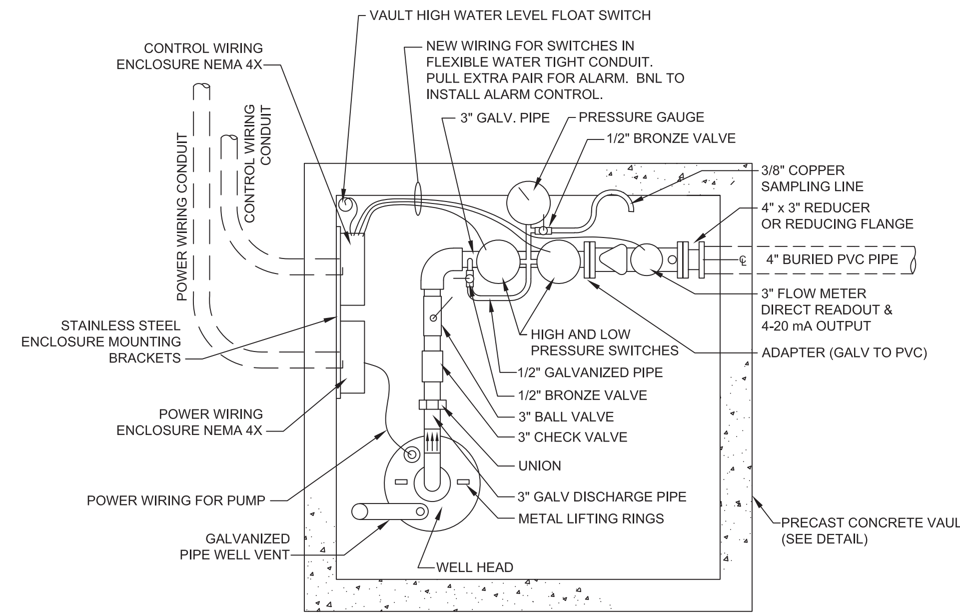


PLAN VIEW



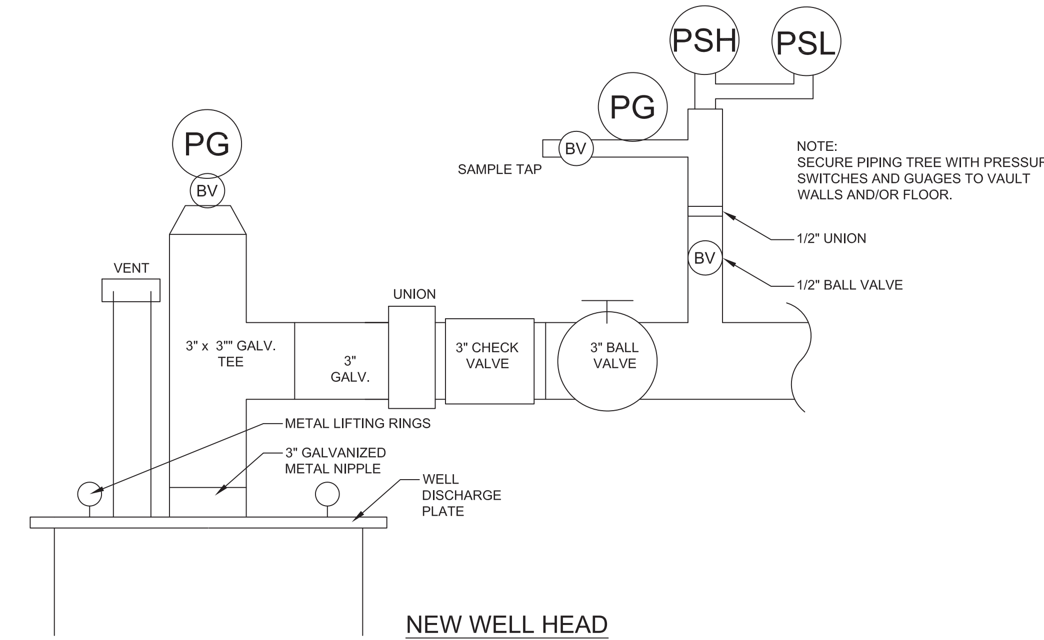
HINGE DETAIL
N.T.S.

NOTE: PROVIDE GROUND CONNECTION TO METAL HATCH, PROVIDE GROUND ROD OR CONNECTION TO WELL CASING MEETING N.E.C. REQUIREMENTS
USE SAME VAULT COVER FOR CHECK VALVE VAULT

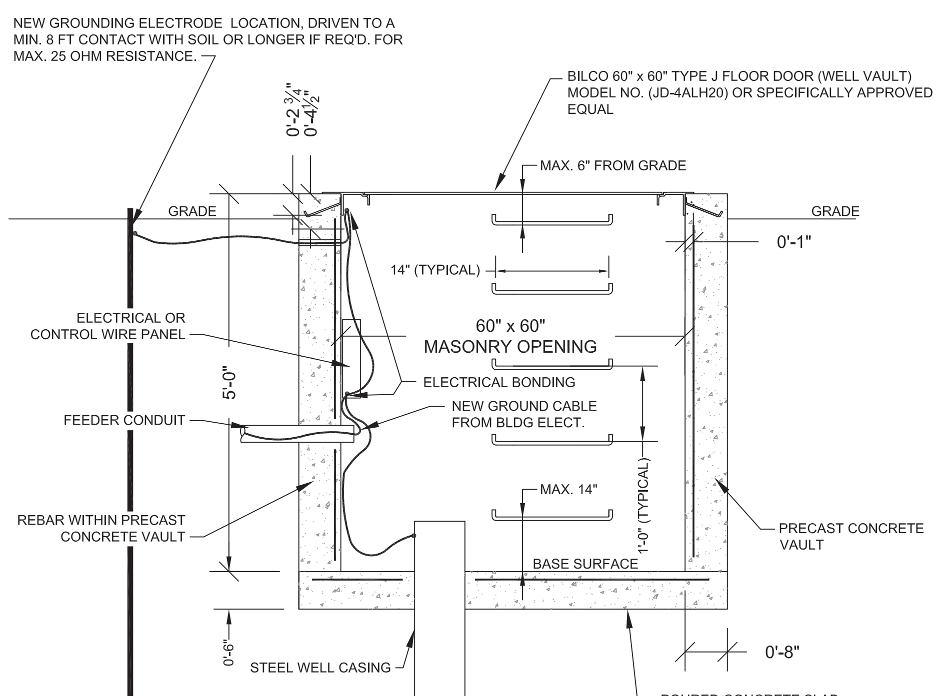


NOTE: NO ELECTRICAL EQUIPMENT TO BE GREATER THAN 50 VOLTS IN WELL HEAD VAULT, EXCLUDING THE PUMP MOTOR.

NEW EXTRACTION WELL VAULT
INTERIOR PIPING AND LAYOUT DETAIL
SCALE: N.T.S.



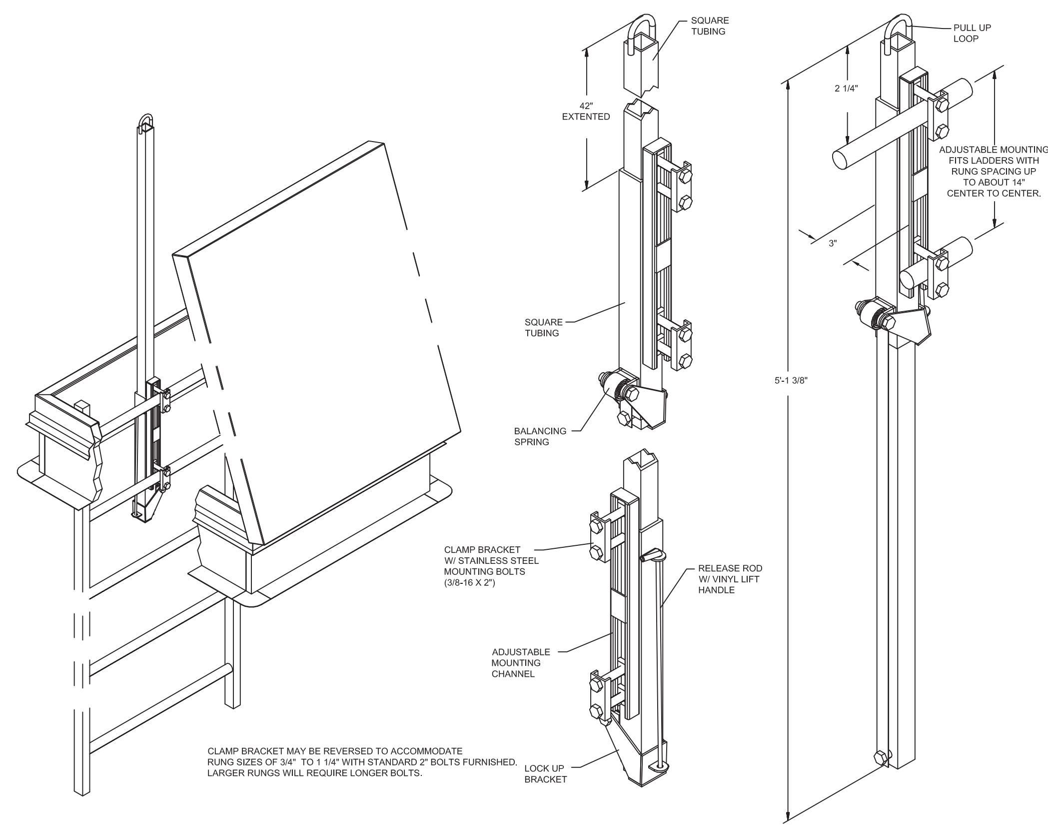
NEW WELL HEAD
CONSTRUCTION DETAIL
SCALE: N.T.S.



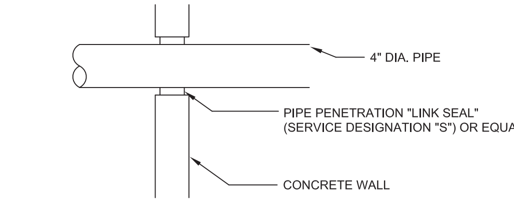
SECTION VIEW

NOTES:
1. The manhole ladder access needs to conform with SBMS requirements.
2. The climber needs a minimum of 15-inches as measured from the rung center to any climbing obstruction.
3. Top rung should be no lower than 6 inches from the upper grade to improve the climbers ability to access on and off.
4. The bottom rung must be no greater than 14 inches from the base surface.

NEW EXTRACTION WELL VAULT
CONSTRUCTION DETAIL
SCALE: N.T.S.



NEW "LADDERUP" SAFETY POST
SCALE: N.T.S.



PASS-THROUGH VAULT DETAIL
N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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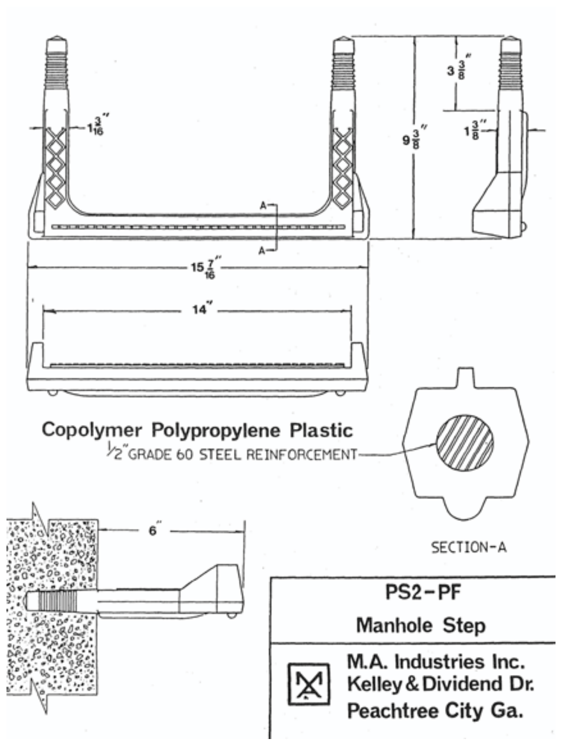
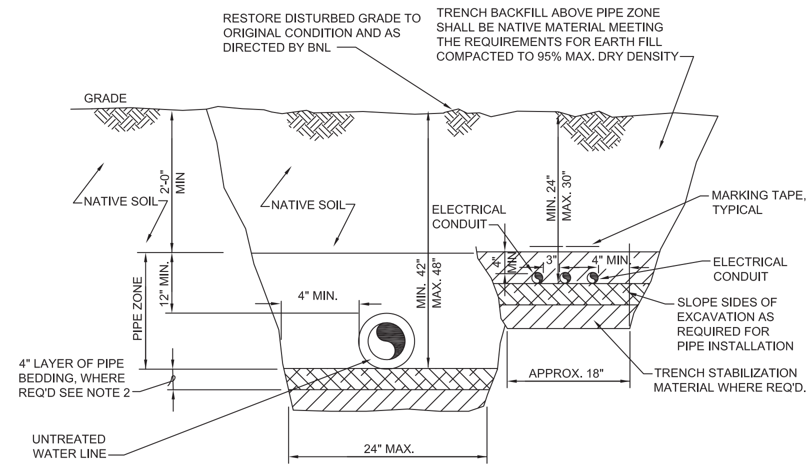
JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: MECHANICAL DETAILS 1 OF 2	
ILR,GPP,LNI, HEW: -	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 29 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: M-4
PROJ. QA: A3-MINOR	APP'D. BY: JRH	BLDG. NO.: -	
PATH:			



NEW VAULT LADDER RUNG DETAIL

SCALE: N.T.S.

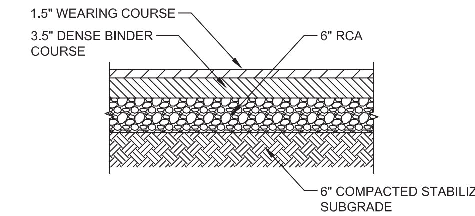


NOTES:

1. PROVIDE 12" MINIMUM SEPARATION BETWEEN ELECTRICAL CONDUITS AND WATER PIPES.
2. IF FIELD ENGINEER CONCURS THAT EXISTING SUBGRADE MEETS REQUIREMENTS FOR PIPE BEDDING, TRENCH BACKFILL, NO EXCAVATION BELOW PIPE ZONE IS REQUIRED. PREPARATION OF TRENCH BOTTOM/ BEDDING MATERIAL SHALL CONFORM TO ANSI/ASTM D1557 STANDARDS.

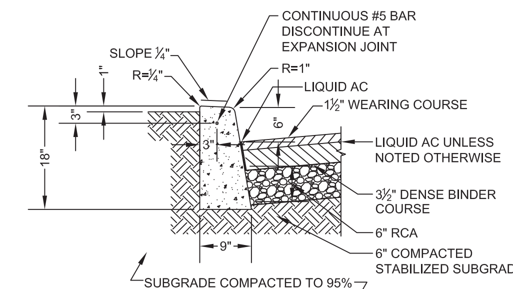
TYPICAL NEW UTILITY TRENCH DETAIL

N.T.S.



ASPHALT PAVING SPECIFICATIONS

N.T.S.

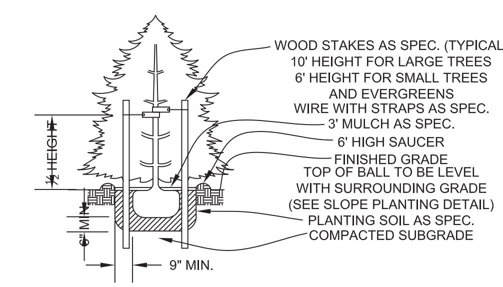


NOTES:

1. CONCRETE SHALL HAVE A COMPRESSIVE STRENGTH OF 4,000 PSI AT 28 DAYS. TEST CYLINDERS STRENGTH MAY BE REQUIRED, AS REQUESTED BY INSPECTOR OR TOWN ENGINEER).
2. CONCRETE SHALL BE A MONOLITHIC POUR. FORMS MUST BE USED FRONT AND REAR.
3. CONCRETE TO CURE 14 DAYS MIN BEFORE ROADWAY PAVING CAN BEGIN.
4. EXPANSION JOINTS TO BE 5 FEET MIN., 20 FEET MAX. O.C.

TYPICAL CONCRETE CURB DETAIL

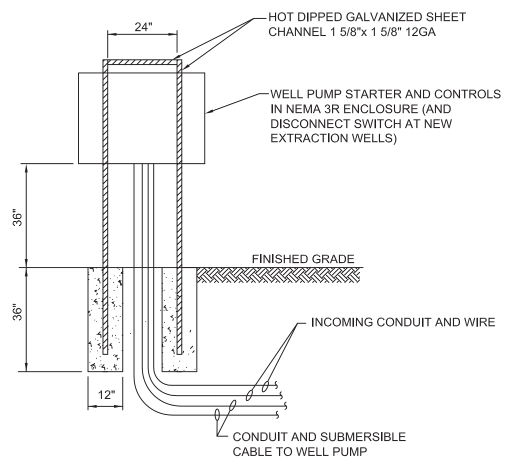
N.T.S.



EVERGREEN TREE

PLANTING DETAIL

N.T.S.



TYPICAL EQUIPMENT MOUNTING DETAIL
ADJACENT TO WELL PUMPS

N.T.S.

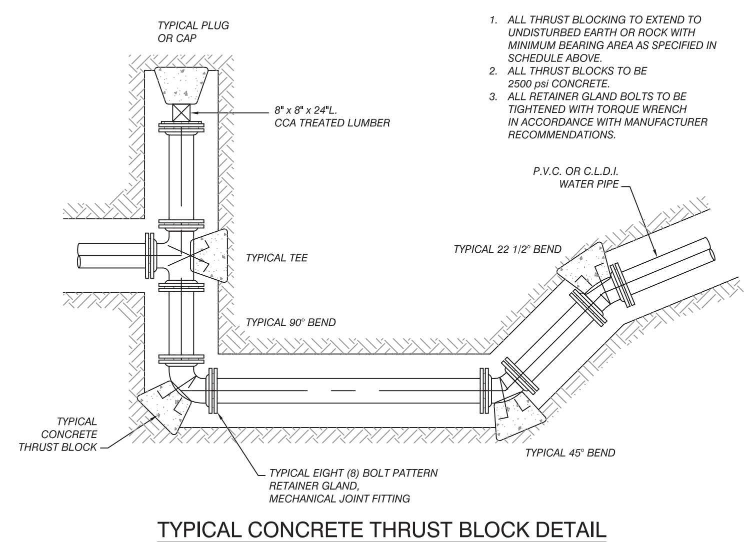
THRUST BLOCK SCHEDULE

MINIMUM SQUARE FEET BEARING AREA ON SOIL FOR THRUST BLOCK

PIPE SIZE	TEES,CAPS & PLUGS	90° BENDS	45° BENDS	22 1/2° BENDS
6" OR LESS	2	3	2	1
8"	4	5	3	2

NOTES:

1. *ALL THRUST BLOCKING TO EXTEND TO UNDISTURBED EARTH OR ROCK WITH MINIMUM BEARING AREA AS SPECIFIED IN SCHEDULE ABOVE.*
2. *ALL THRUST BLOCKS TO BE 2500 psi CONCRETE.*
3. *ALL RETAINER GLAND BOLTS TO BE TIGHTENED WITH TORQUE WRENCH IN ACCORDANCE WITH MANUFACTURER RECOMMENDATIONS.*



TYPICAL CONCRETE THRUST BLOCK DETAIL

N.T.S.

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

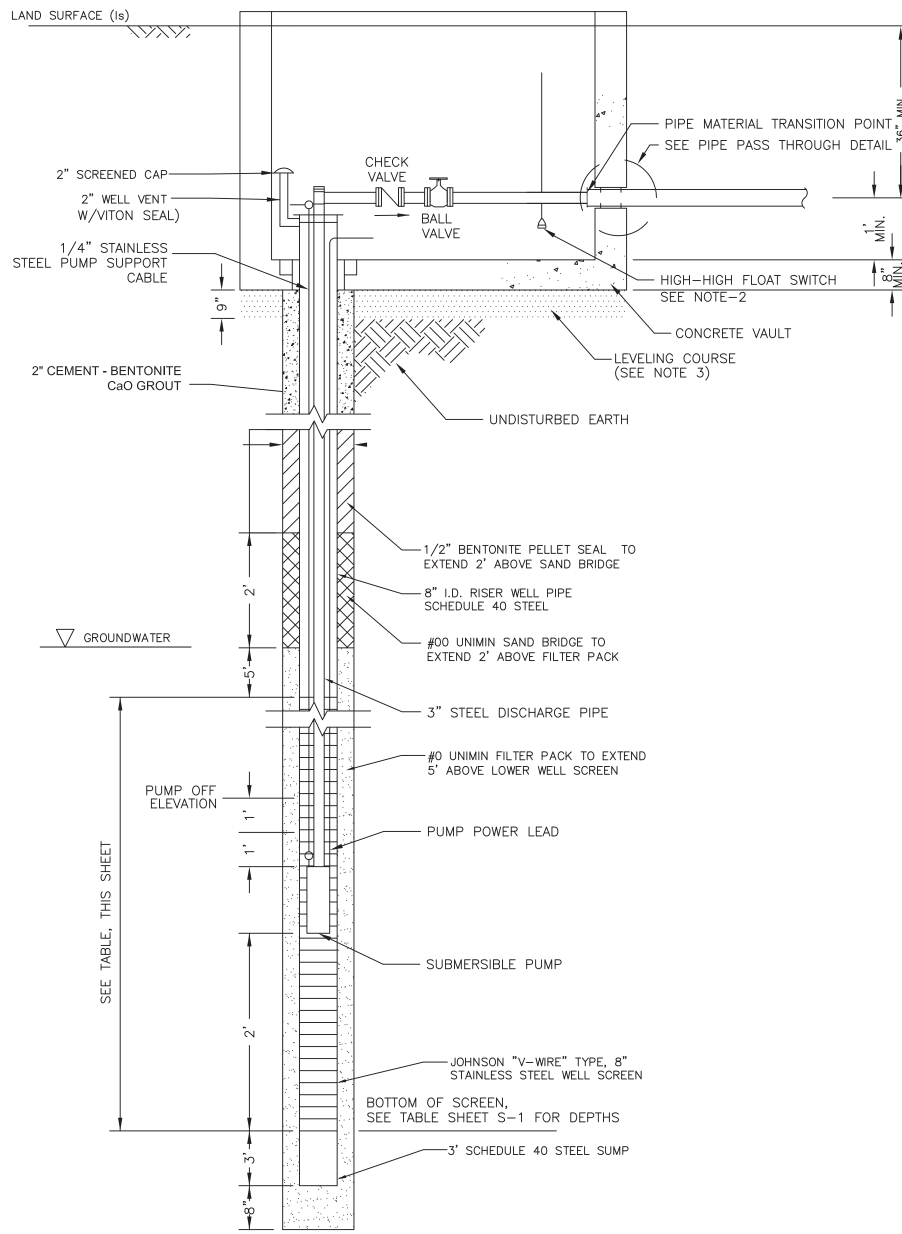
BROOKHAVEN NATIONAL LABORATORY

UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
ENVIRONMENTAL MANAGEMENT DIRECTORATE & ENVIRONMENTAL PROTECTION DIVISION
UPTON, NEW YORK 11973

STATE OF NEW YORK · JAMES R. HOLZMACHER · No. 66054 · LICENSED PROFESSIONAL ENGINEER

J.R. HOLZMACHER P.E., LLC
The Third Generation of Excellence In
Water Supply, Water Resources, Civil and Environmental Engineering
3555 Veterans Memorial Highway, Suite A, Ronkonkoma NY 11779
PHONE: (631) 234-2220 FAX: (631) 234-2221 E-MAIL: info@holzmacher.com

JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: MECHANICAL DETAILS 2 OF 2	
ILR,GPP,LNI, HEM: -	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 30 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: M-5
PROJ. QA: A3-MINOR	APP'D. BY: JRH	BLDG. NO.: -	
PATH:			



NEW EXTRACTION WELL IN VAULT

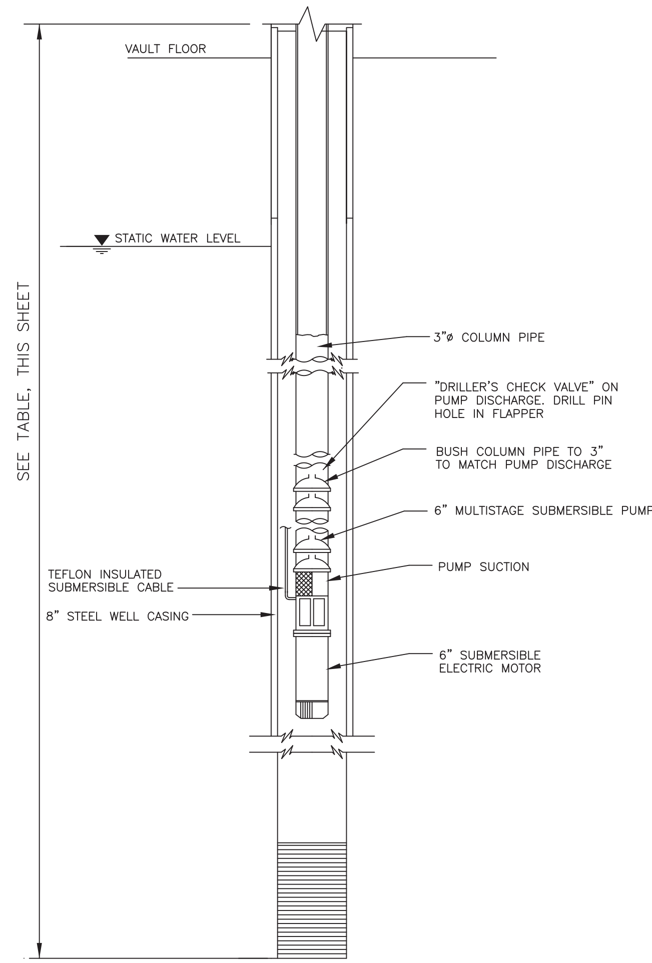
N.T.S.

WELL VAULT PIPING NOTES:

1) PRESSURE TRANSDUCER LEVEL CONTROL; HIGH-HIGH FLOAT SWITCH IS USED TO PROTECT THE WELL VAULT.

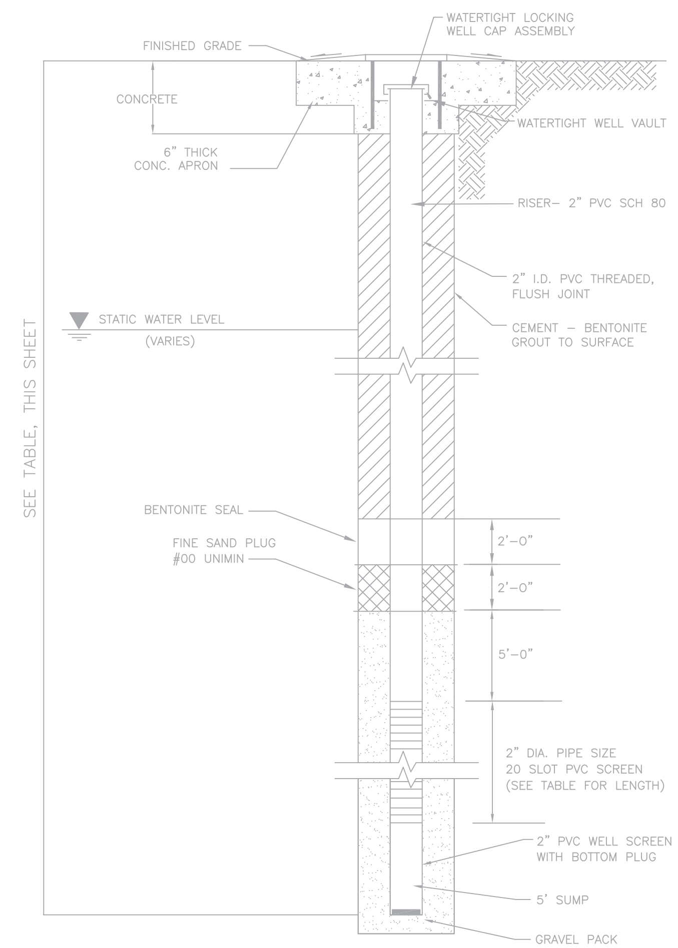
2) LEVELING COURSE SHALL BE NYSDOT TYPE 3 STONE.

3) CONTRACTOR TO DESIGN/INSTALL EXTRACTION WELL SCREEN PER SPECIFICATION 02670 PART II 2.03.



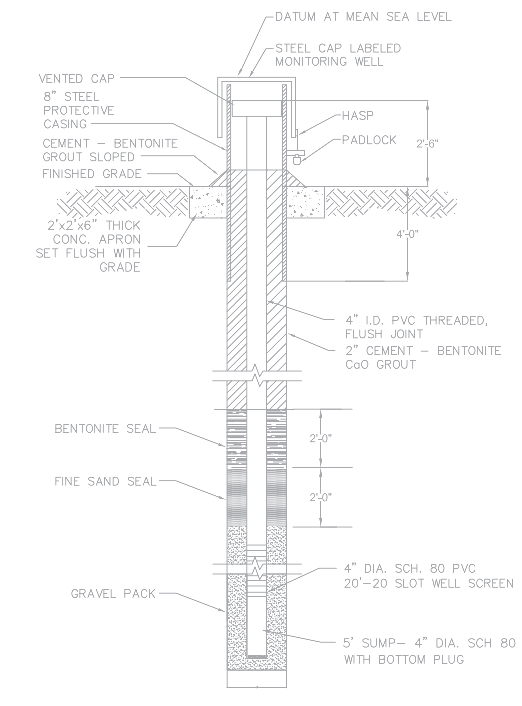
NEW SUBMERSIBLE EXTRACTION WELL PUMP INSTALLATION DETAIL

N.T.S.



TYPICAL NEW MONITORING WELL DETAIL "FLUSH TYPE"

N.T.S.



TYPICAL NEW MONITORING WELL DETAIL "STICK-UP TYPE"

N.T.S.

NEW MONITORING WELLS UNDER SEPARATE CONTRACT

FINAL DESIGN

JOB NO.	SHEET	NO	REVISION	DATE	DWN.	APP'D.	QA

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UPTON, NEW YORK 11973

JOB TITLE: PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		DWG. TITLE: EXTRACTION & MONITORING WELL DETAILS	
ILR,GPP,LNI, HEW: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 31 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: W-1
PROJ. QA: A3-MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH:			

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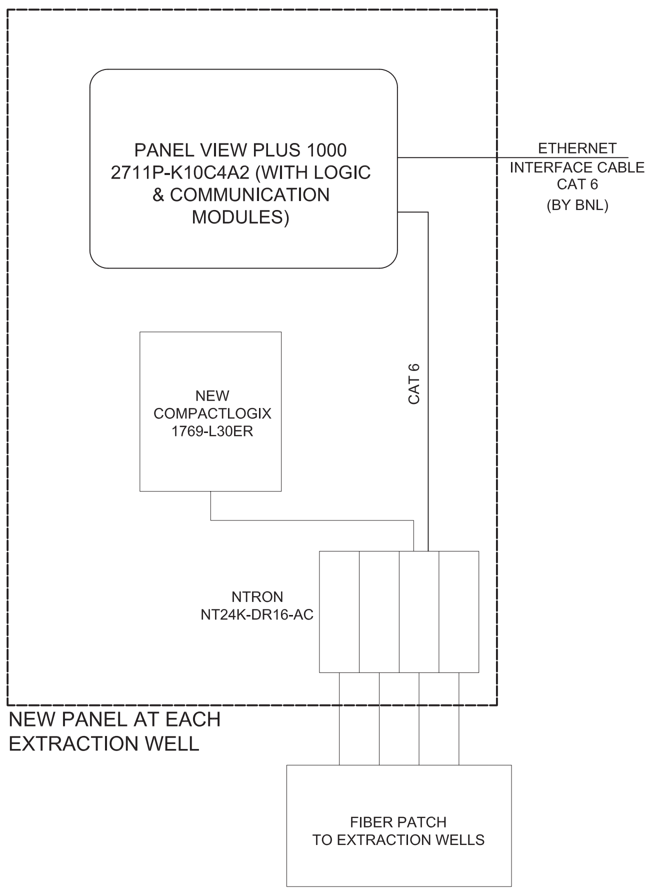
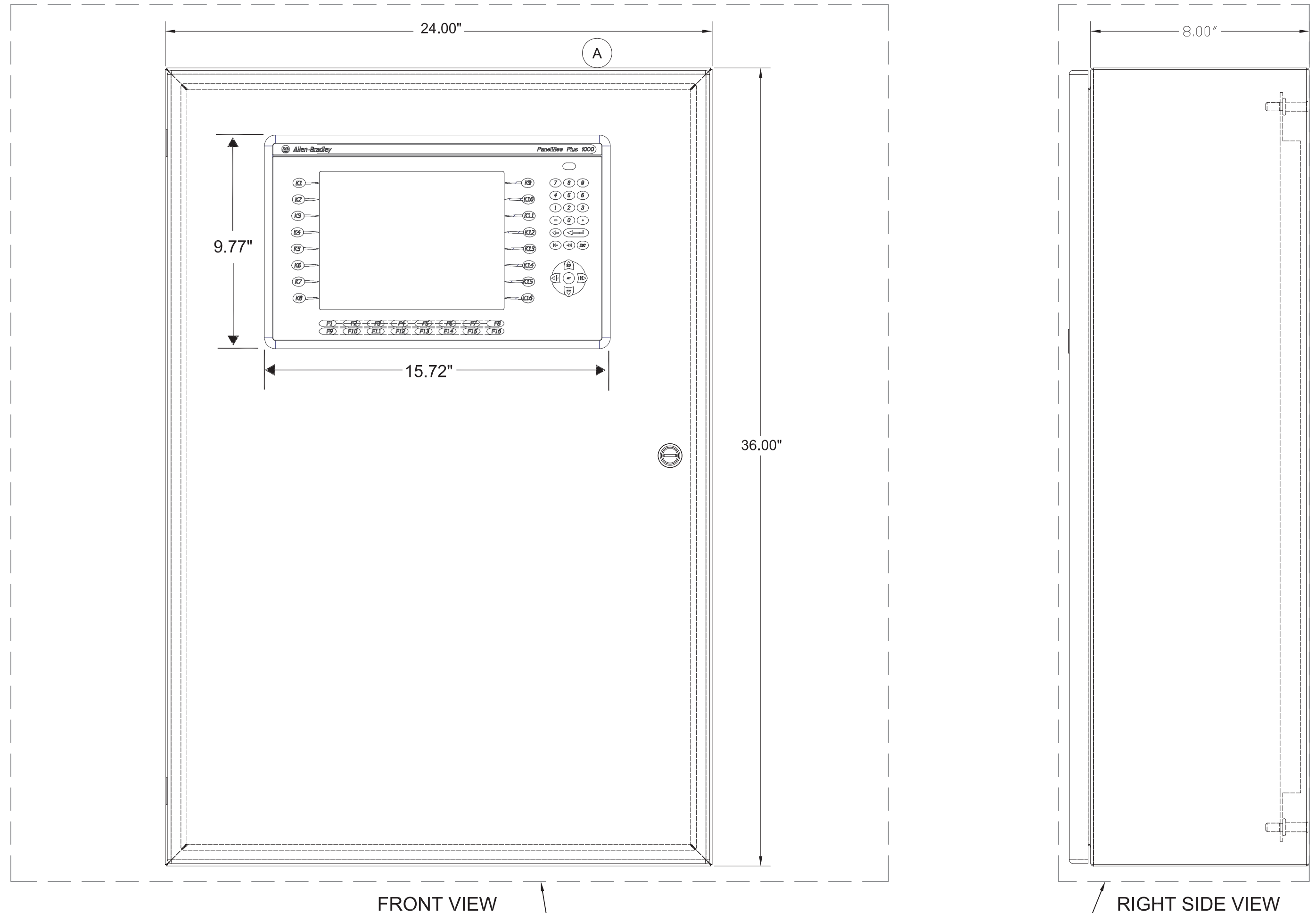
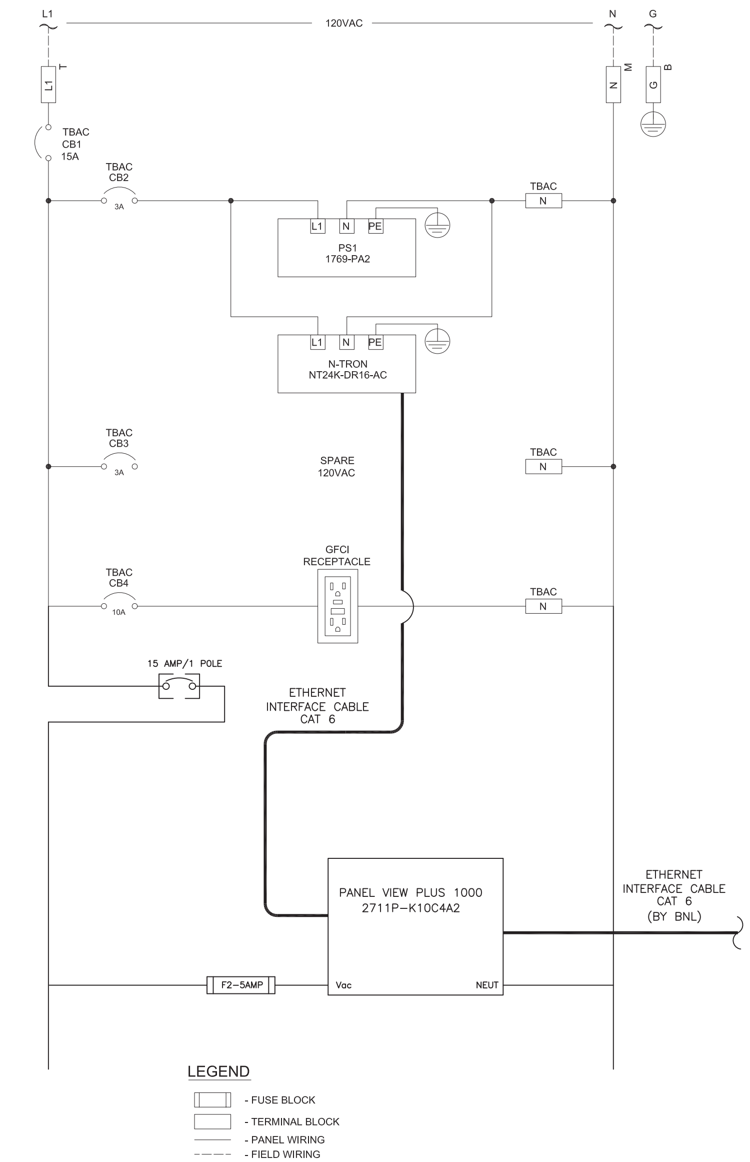


SYSTEM ARCHITECTURE
N.T.S.



NEW STAINLESS STEEL SECONDARY EXTERIOR ENCLOSURE 42x42x12 FOR HOUSING CONTROL PANEL WITH PANELVIEW PLUS 1000 INTERFACE. ENCLOSURE SHALL BE MOUNTED ON KINDORF. OUTSIDE OF BUILDING 749 ONLY.

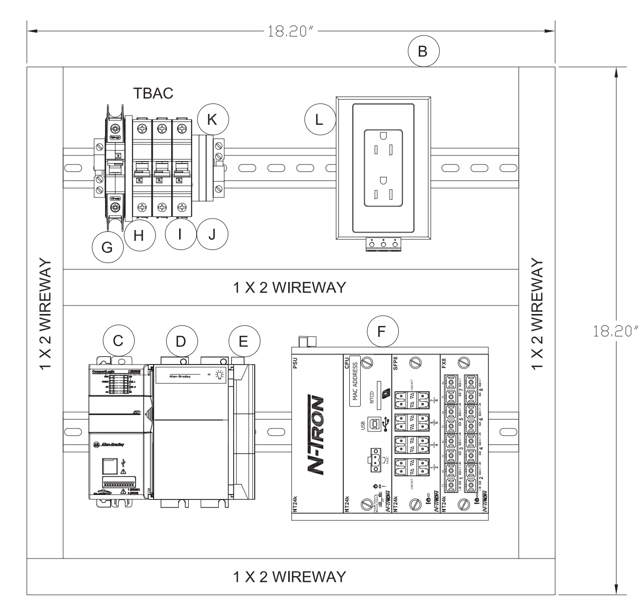
PANEL ARRANGEMENT
N.T.S.



POWER DISTRIBUTION
N.T.S.

Item	Quantity	Description	Manufacturer	Part Number
A	1	Concept Enclosure, Type 4 and 12	Hoffman	CSD36248SS6
B	1	Concept Sub Panel	Hoffman	CP2020
C	1	CompactLogix 5370 L2 Controller	Allen-Bradley	1769-L30ER
D	1	Power Supply 120/240 VAC, 2 Amp	Allen-Bradley	1769-PA2
E	1	Right End Cap/Terminator	Allen-Bradley	1769-ECR
F	1	Modular Managed Ethernet Switch, DC	N-Tron/Red Lion	NT24K-DR16-AC
	1	8 Port 10/100/1000 Base T Module	N-Tron/Red Lion	NT24K-TX8
	1	8 100 Base FX, Singlemode Fiber Ports	N-Tron/Red Lion	NT24K-FXE8-ST-15
	120VAC Power Distribution			
G	1	Miniature Circuit Breaker, 15 Amp	Allen-Bradley	1489-M1C150
H	1	Modular Terminal Block, UT 4-PE/L/L	Phoenix Contact	3214360
I	2	Supplementary Protectors, 1 Pole, 3 Amp	Allen-Bradley	1492-SPM1C030
J	1	Supplementary Protectors , 1 Pole, 10 Amp	Allen-Bradley	1492-SPM1C100
K	3	Feed-through Terminal Block, UT 4-MTD, finger safe	Phoenix Contact	3046184
L	1	Socket, EM-DUO/120/15/GFI	Phoenix Contact	5600462
M	A/R	Wire, Wireway, Labels, End Stops, End Anchors, Etc.		

INTERNAL PANEL SCHEDULE
N.T.S.



INTERNAL PANEL ARRANGEMENT
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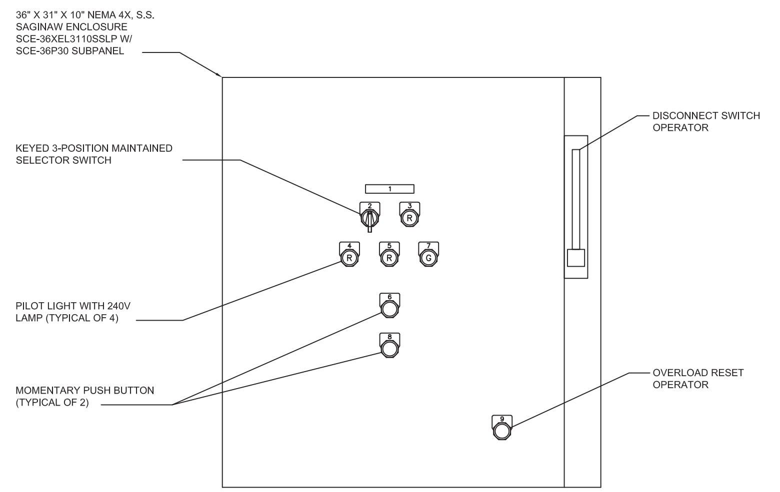
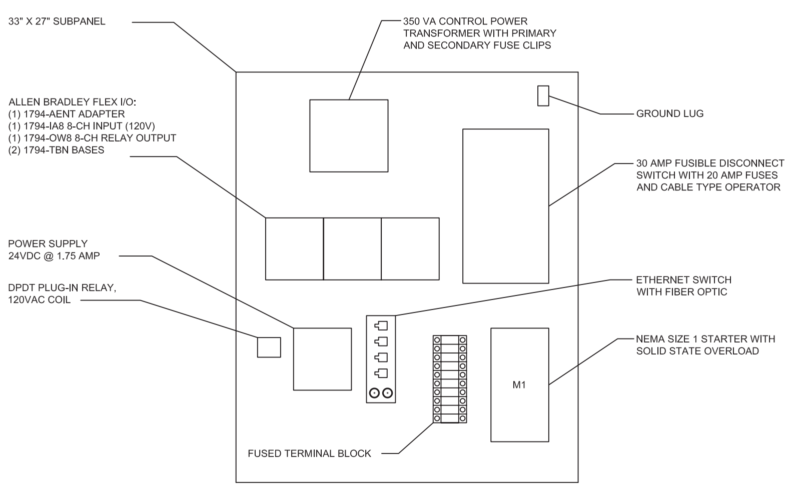
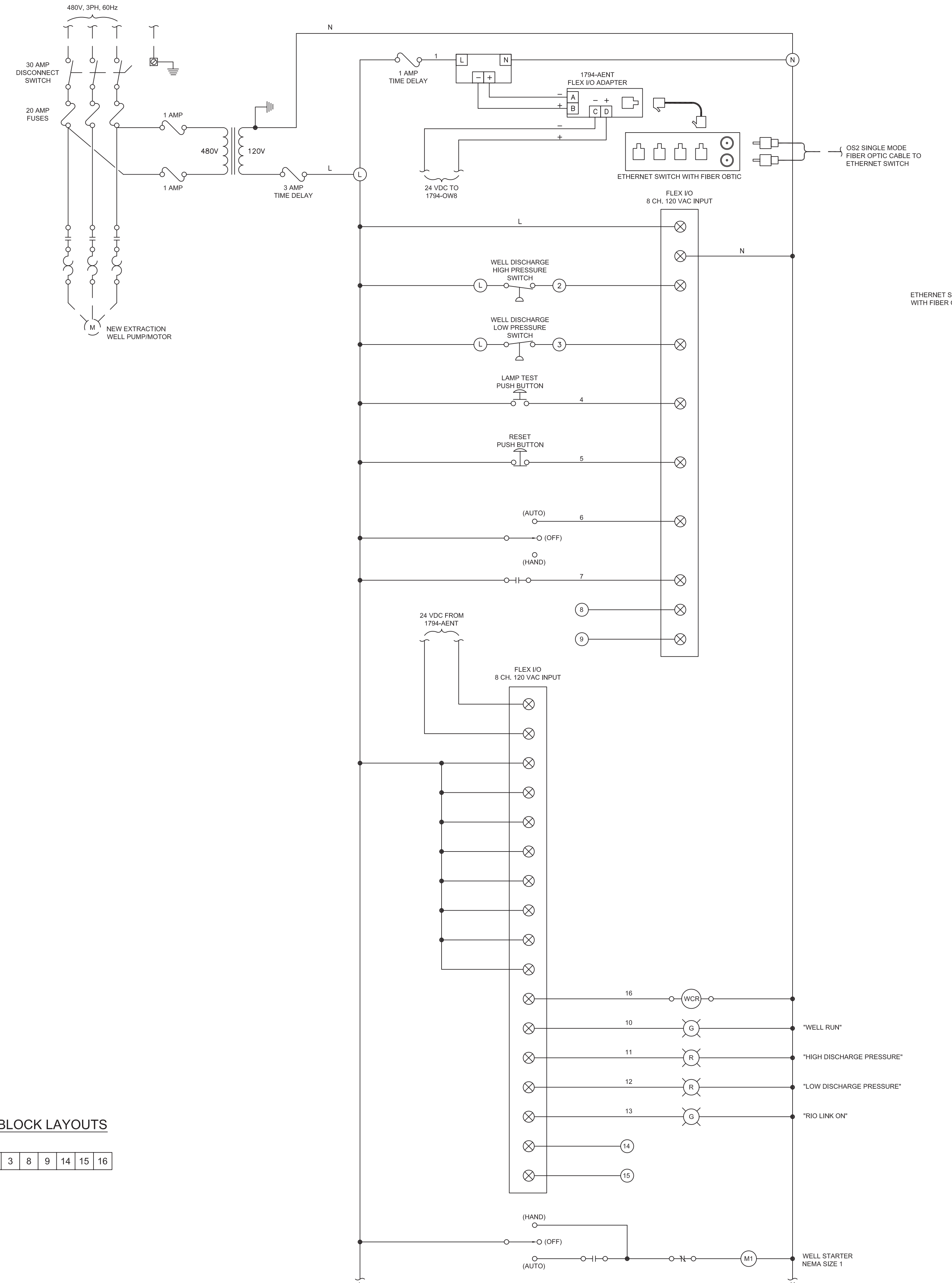
JOB TITLE		DWG. TITLE	
PFAS SOURCE AREA GROUNDWATER REMEDIATION PROJECT		COMMUNICATIONS AND CONTROLS – 1 OF 2	
ILR,GPP,LNI, HEW –	DATE 4/1/2021	ACCT. NO. 21097	SHEET 32 OF 33
SCALE AS SHOWN	DWN. BY AJZ	JOB NO. 14011	DWG. NO. CC-1
PROJ. QA A3-MINOR	APP'D. BY JRH	BLDG. NO. –	
PATH:			



WELL CONTROL PANEL DOOR ARRANGEMENT
(11 REQUIRED)

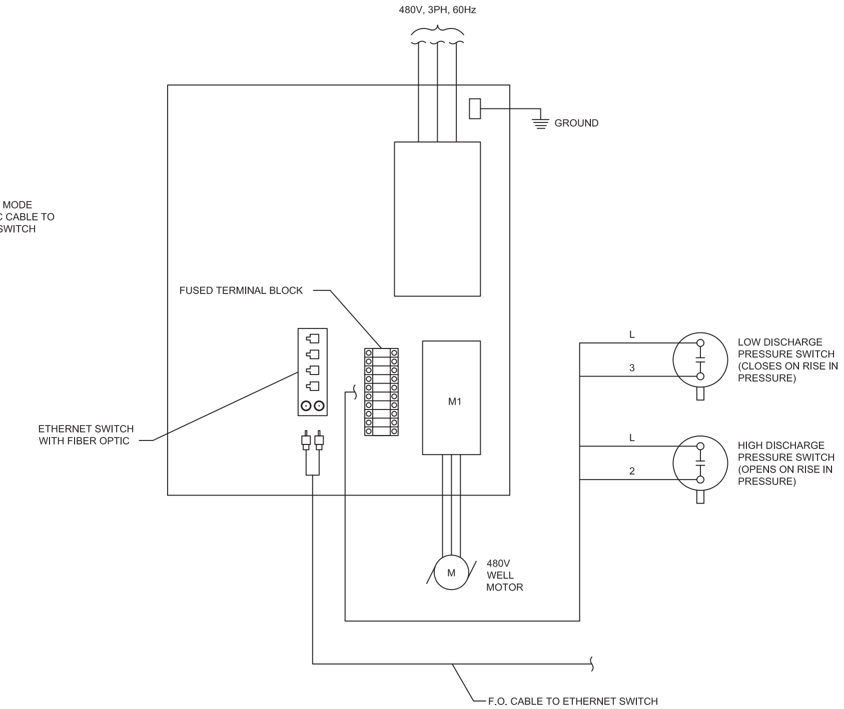


WELL CONTROL PANEL SUBPANEL ARRANGEMENT
(11 REQUIRED)



CONTROLS LADDER WIRING DIAGRAM

(NEW PANEL AT EACH EXTRACTION WELL)



INTERCONNECTING WIRING DIAGRAM AT ALL EXTRACTION WELLS

NAMEPLATE SCHEDULE

NP#	QTY	NAMEPLATE INSCRIPTION	SIZE / (LENS)
1	1	WELL CF-RW-A	75H" X 4W"
2	1	HAND OFF AUTO	1.1875"
3	1	RUN	1.00"
4	1	HIGH DISCHARGE PRESSURE	1.00"
5	1	LOW DISCHARGE PRESSURE	1.00"
6	1	RESET	1.1875"
7	1	RIO LINK ON	1.00"
8	1	LAMP TEST	1.00"
9	1	OVERLOAD RESET	1.1875"

TERMINAL BLOCK LAYOUTS

TB1

L	L	N	2	3	8	9	14	15	16

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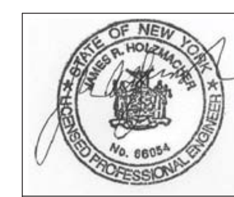

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ILR,GPP,LNI, HEM: –	DATE: 4/1/2021	ACCT. NO.: 21097	SHEET 33 OF 33
SCALE: AS SHOWN	DWN. BY: AJZ	JOB NO.: 14011	DWG. NO.: CC–2
PROJ. QA: A3–MINOR	APP'D. BY: JRH	BLDG. NO.: –	
PATH:			

Appendix A
Remediation System Design Calculations

Narrative
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Per- and Poly- Fluoroalkanated Substances (PFAS) have been detected at several locations within the BNL campus and investigation of their incidence in soils and groundwater is underway. Detections of PFAS at low concentrations have been made in many areas but two source areas have been identified within the vicinity of the Current Fire House (CF) and the Former Fire House (FF). Investigation of the Former Fire House is complicated by the presence of a new building over the former location of the fire house as well as the practice and drill areas which were in use before the building was torn down.

Source Area Removal Actions are being undertaken for each of the Current Fire House and Former Fire House areas. These actions consist of, in part, construction of two new groundwater pump and treat remediation systems. Each system will include one or more extraction wells within the immediate vicinity of the source area plus lines of wells to transect the plume downgradient. Although this is a Source Area Removal Action multiple trransect well lines will be considered within the design and will be included within the construction bid as alternate bid items. These may be constructed together with the Source Removal activities if funding allows.

Numerous different members of the PFAS family of compounds have been detected within groundwater at BNL but NYS has establihed MCL's in drinking water only for PFOS and PFOA. Laboratory data generated during delineation activities suggest that PFOS is the predominant compound of interest.

Goals of these Source Removal activities include:

"- establishing hydraulic control over the immediate source areas.

"- capture of portions of the identified plues having total PFOS concentrations in excess of 100 ng/L.

"- collection of operational data during PFAS treatment to allow better prediction of future operating costs for other PFAS compounds at these sites and at other remediation sites, and for evaluation of other treatment technologies.

Constraints include:

"- Schedule : a rapid implementation is required so reuse of exisitng components must be considered.

"- Cost: reuse of existing remediation system components will be considered to reduce costs to remediate beyond the source area to the extent practical.

"- Flexibility: future improvements in PFAS specifc resins are anticipated to reduce long term operating costs, and additional PFAS compounds may be added to the SPDES discharge permit in the future. The extraction and treatment systems must reasonably accommodate changes to pumping rates and treatment components during future operation.

"- Regualtory Flexibility: future requirements for spent GAC disposal are unknown but changes are anticipated. Flexibility in design of the remediation is needed to be able to meet future operating constraints at reasonable cost.

Treatment system design is specific to each source. Design sheets are designated as CF for Current Firehouse and FF for the Former Firehouse. Modeling of the remediation well pumping rates is not yet complete but will be estimated for pipe and pump sizing for the 30% and 90% design by assuming a fow rate of 100 gpm per well, whereas the average flow rate anticipated after GW modeling is 50 to 75 gpm per well. The well screen depths are also estimated at this stage of design.

Current Firehouse (CF) Treatment System:

The Current Firehouse source area is accessible for construction of extraction wells and pipe runs. The source area contains a ground water plume which is believed to be fed by PFAS compounds in the soils above the water table. Soil remediation is not included within this immediate project.

Treatment of pumped water will be accomplished through GAC filtration, although this may be switched to a specific resin in the future if operational benefits are forecast. Treated water will be discharged to the HP basins or the adjacent OU III basin. The former hospital reactor well and its associated GAC filter unit were housed in Building 492. The GAC filter is no longer installed but the building is sized for a pair of 10 foot diameter vessels and is available for reuse. Discharge piping runs from the medical clinic to the HP basins and that piping will also be reused.

Purchase of a replacement GAC filtration unit is recommended and is now underway. The pre-purchased unit will be loaded into Building 492 to be available for reconnection by the selected Mechanical Contractor.

Narrative
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Former Firehouse (FF) Treatment System:

The source area is covered by a building and the area immediately down gradient is occupied by a busy street that contains extensive buried utilities. The plume appears to track beneath the active NSLS II facility. These factors require placement of remediation wells and routing of piping in areas that would otherwise be considered inefficient.

The source area well(s) will be placed south of Brookhaven Avenue in order to avoid utility conflicts and to simplify drilling and construction activities. Expansion of existing buildings into this general area is anticipated so pipe and conduit routing will veer toward the west to reduce future conflicts.

Discharge of treated water is planned for the existing RA V basin. A Calgon Model 10 GAC filter exists at the site and will be reutilized for treatment of the FF Source Removal groundwater. The vessels will need to be renovated, which will include recoating of the interior epoxy lining, replacement of interior underdrain inlet strainer nozzles, and replacement of exterior valves. The GAC vessels sit on an exterior slab. Piping is wrapped with insulation but construction of a metal frame building to enclose the large and small piping is recommended.

The treatment system design is based upon a maximum flow rate of 750 gpm per vessel for a capacity of 750 gpm when operating in series and 1,500 gpm when operating in parallel. Piping from the source area will pass down the west side of the NSLS II facility and will meet an exisitng 6-inch diameter run of remediation piping which is available for reuse. That pipe run passes up the east side of the NSLS II facility to the RA V basin and was originally installed for the Tritium remediation system.

Groundwater modeling has not yet ben completed to verify pumping rates necessary to capture the plume from the available well locations. Prediction of the mix and concentration of contaminants influent to the treatment system has not yet been modeled and the discharge permit monitoring requirements have not been established. Discharge to drinking water standards of 10 ng/L for each of PFOS and PFOA is assumed. Other PFAS compounds will adsorb on the GAC but the frequency of carbon change out will dictate which compounds may be present in the treatment system effluent.

An initial scenario is based on the maximum contaminant concentrations seen for each contaminant within the Vertical Profile Borings during the GW investigation while using an effective dilution rate of 300%. Process modeling of the treatment system can only be done at this point for PFOS and PFOA as Freundlich adsorption data are not available for many other PFAS compounds.

The PFC contaminants listed below include all 21 species which are revealed on the sampling protocol adopted for the 2018 ground water investigation and may not be found to fully represent the source areas once full delineation is completed. It is worth noting that samples from the Potable wells are based on methodology for the Unregulated Contaminant Monitoring Rule (UCMR) and includes only 6 members of the PFC family of compounds.
"UCMR 6" compounds are highlighted in blue in the tables below.

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Narrative

Table 1 - BNL - PFCs Detected in BNL Eastern Supply Well Field 2 Year Contributing Area

	Contaminants:		Maximum Concentration		
Carbon Chain Length	**Abbreviation**	**Name**	**GeoProbe Wells**	**Potable Wells**	**Max Detection**
4	PFBA	Perfluorobutyric Acid	175 ng/l	ng/l	175
4	PFBS	Perfluorobutanesulfonate	2.1 ng/l	1.9 ng/l	2.1
5	PFPeA	Perfluoropentanoic Acid	7.2 ng/l	ng/l	7.2
5	PFPeS	Perfluoropentanesulfonate	0.9 ng/l	ng/l	0.9
6	PFHxA	Perfluorohexanoic Acid	5.6 ng/l	ng/l	5.6
6	PFHxS	Perfluorohexanesulfonate	16.8 ng/l	9.1 ng/l	16.8
7	PFHpA	Perfluoroheptanoic Acid	0 ng/l	2.6 ng/l	2.6
7	PFHpS	Perfluoroheptanesulfonate	0 ng/l	ng/l	0
8	PFOA	Perfluorooctanoic Acid	7.2 ng/l	6.6 ng/l	7.2
8	PFOS	Perfluorooctanesulfonate	16.4 ng/l	18.9 ng/l	18.9
8	PFOSA	Perfluorooctanesulfonamide	0 ng/l	ng/l	0
8 + 1	8 + 1 Acid	N-methylperfluoro-1-octanesulfonamidoacetic acid	0 ng/l	ng/l	0
8 + 2	8 + 2 Acid	N-ethylperfluoro-1-octanesulfonamidoacetic acid	0 ng/l	ng/l	0
9	PFNA	Perfluorononanoic Acid	1.6 ng/l	2.7 ng/l	2.7
9	PFNS	Perfluorononanesulfonate	0 ng/l	ng/l	0
10	PFDA	Perfluorodecanoic Acid	0 ng/l	ng/l	0
10	PFDS	Perfluorodecanesulfonate	0 ng/l	ng/l	0
11	PFUDA	Perfluoroundecanoic Acid	0 ng/l	ng/l	0
12	PFDoA	Perfluorododecanoic Acid	0 ng/l	ng/l	0
13	PFTrDA	Perfluorotridecanoic Acid	0 ng/l	ng/l	0
14	PFTeDA	Perfluorotetradecanoic Acid	0 ng/l	ng/l	0

Indicates a UCMR3 Sampling Protocol Compound

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Table 2 - BNL - PFCs Detected in BNL Western Supply Well Field 2 Year Contributing Area

	Contaminants:		Maximum Concentration			
Carbon Chain Length	Abbreviation	Name	GeoProbe Wells	Potable Wells	Max Detection	Design Basis
4	PFBA	Perfluorobutyric Acid	60 ng/l	ng/l	60	175 ng/l
4	PFBS	Perfluorobutanesulfonate	223 ng/l	0 ng/l	223	223 ng/l
5	PFPeA	Perfluoropentanoic Acid	127 ng/l	ng/l	127	127 ng/l
5	PFPeS	Perfluoropentanesulfonate	626 ng/l	ng/l	626	626 ng/l
6	PFHxA	Perfluorohexanoic Acid	564 ng/l	ng/l	564	564 ng/l
6	PFHxS	Perfluorohexanesulfonate	3710 ng/l	8.9 ng/l	3710	3710 ng/l
7	PFHpA	Perfluoroheptanoic Acid	72 ng/l	0 ng/l	72	72 ng/l
7	PFHpS	Perfluoroheptanesulfonate	23 ng/l	ng/l	23	23 ng/l
8	PFOA	Perfluorooctanoic Acid	144 ng/l	0.9 ng/l	144	144 ng/l
8	PFOS	Perfluorooctanesulfonate	2980 ng/l	24 ng/l	2980	2980 ng/l
8	PFOSA	Perfluorooctanesulfonamide	330 ng/l	ng/l	330	330 ng/l
8 + 1	8 + 1 Acid	N-methylperfluoro-1-octanesulfonamidoacetic acid	0 ng/l	ng/l	0	0 ng/l
8 + 2	8 + 2 Acid	N-ethylperfluoro-1-octanesulfonamidoacetic acid	0 ng/l	ng/l	0	0 ng/l
9	PFNA	Perfluorononanoic Acid	40 ng/l	0 ng/l	40	40 ng/l
9	PFNS	Perfluorononanesulfonate	2.6 ng/l	ng/l	2.6	2.6 ng/l
10	PFDA	Perfluorodecanoic Acid	0 ng/l	ng/l	0	0 ng/l
10	PFDS	Perfluorodecanesulfonate	0 ng/l	ng/l	0	0 ng/l
11	PFUDA	Perfluoroundecanoic Acid	0 ng/l	ng/l	0	0 ng/l
12	PFDoA	Perfluorododecanoic Acid	0 ng/l	ng/l	0	0 ng/l
13	PFTrDA	Perfluorotridecanoic Acid	0 ng/l	ng/l	0	0 ng/l
14	PFTeDA	Perfluorotetradecanoic Acid	0 ng/l	ng/l	0	0 ng/l
	Indicates a UCMR3 Sampling Protocol Compound					9,016.6 ng/l

Basis of Design
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Remediation well screen locations have been selected based on the groundwater samples collected during characterization of the groundwater plumes. Groundwater modeling is being performed to optimize well flow rates and screen intervals, and to reduce the amount of 1,4 Dioxane which may be captured by the remediation wells but which would not be removed by the GAC Filtration system. The groundwater modeling is not yet completed so projections of contaminant concentrations influent to the treatment system are developed using the plume concentrations revealed during plume characterization with assumed dilution factors.

The remediation wells are each designed to operate at up to 100 gpm, although the total combined flow rate is limited to 750 gpm. The GAC filtration treatment system can be oeprated at up to 1,500 gpm if the vessels are run in parallel but carbon use will be more efficient if run in series. Operating costs for GAC consumption are projected based on available Freundlich Isotherm data for PFOS and PFOA although there is much contradictory published data. Isotherm data for the other PFAS compounds which may be encountered are either unavailable or not considered reliable.

The calculation sheets are linked to the Freundlich parameters in the table below. This will allow rapid updating of GAC consumption calulations if a different carbon is used or if more reliable values become available.

Carbon Chain Length	Contaminants: Abbreviation	Freundlich Parameters (Filtrasorb 400) K (mg/g) (L/mg)	1/n
4	PFBA		
4	PFBS	113	0.98
5	PFPeA		
5	PFPeS		
6	PFHxA	39400	1.45
6	PFHxS	21400	1.52
7	PFHpA		
7	PFHpS		
8	PFOA	14.317	0.2504
8	PFOS	25.9	0.9
8 + 1	8 + 1 Acid		
8 + 2	8 + 2 Acid		
9	PFNA		
9	PFNS		
10	PFDA		
10	PFDS		
11	PFUDA		
12	PFDoA		
13	PFTrDA		
14	PFTeDA		

Basis of Design
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Prediction of the influent contaminant levels must be carried out for each treatment system, which can be fed by many combinations of the ten wells at the Current Fire House and three wells at the Former Fire House systems.

Contaminant concentrations at the intended well screen depths are tabulated below.

Basis of Design

Current Fire House

Well No.		**Design Flow Rate:**	**Assumed Pumping Dilution**	PFOS (ng/L)	PFOA (ng/L)	1,4 Dioxane (ug/L)
CF-RW	A	100 gpm	300%	5,000	150	0.0
CF-RW	B	100 gpm	300%	800	25	0.0
CF-RW	C	50 gpm	300%	100	2	0.0
CF-RW	D	100 gpm	300%	500	15	0.0
CF-RW	E	50 gpm	300%	900	25	0.0
CF-RW	F	75 gpm	300%	110	5	3.0
CF-RW	G	100 gpm	300%	250	10	3.0
CF-RW	H	75 gpm	300%	75	5	1.0
Treatment system influent:		650 gpm		368.65	11.33	0.31
			GAC consumption:	9.7936	pounds per day	

Former Fire House

Well No.		**Design Flow Rate:**	**Assumed Pumping Dilution**	PFOS (ng/L)	PFOA (ng/L)	1,4 Dioxane (ug/L)
FF-RW	A	100 gpm	300%	2,500	200	0.0
FF-RW	B	100 gpm	300%	100	50	0.1
FF-RW	C	100 gpm	300%	300	150	0.25
Treatment system influent:		300 gpm		322.22	44.44	0.04
			GAC consumption:	4.46	pounds per day	

denotes variable input field

Well Flow Rates
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Pumping rated for each remediation well will be established and verified by groundwater modeling. However, the sizing of each well and pipe line is performed by assuming a full flow capacity of 100 gpm. While this will be the peak capacity of each well it is assumed that most wells will operate at 50 to 75 gpm and that the combined flow rate for the treatment system will be 750 gpm.

Design of each Remediation System is based on the wells operating at the following flow rates:

Current Firehouse (CF) GW Remediation System

Well No.		Design Flow Rate:		TDH (Feet H2O)	Motor (HP)	Recommended Motor (HP)	Rough Grade Elevation	
CF-RW	A	100	gpm	156.60	4.94	5	86	Ft. MSL
CF-RW	B	100	gpm	160.74	5.07	5	84	Ft. MSL
CF-RW	C	50	gpm	116.53	1.84	5	100	Ft. MSL
CF-RW	D	100	gpm	121.46	3.83	5	100	Ft. MSL
CF-RW	E	50	gpm	114.94	1.81	5	100	Ft. MSL
CF-RW	F	75	gpm	123.24	2.92	5	90	Ft. MSL
CF-RW	G	100	gpm	114.18	3.60	5	96	Ft. MSL
CF-RW	H	75	gpm	106.79	2.53	5	98	Ft. MSL
			System Total:	650 gpm				

Former Firehouse (FF) GW Remediation System

Well No.		Design Flow Rate:		TDH (Feet H2O)	Motor (HP)	Recommended Motor (HP)	Rough Grade Elevation	
FF-RW	A	100		193.95	6.12	7.5	72	Ft. MSL
FF-RW	B	100		203.14	6.41	7.5	66	Ft. MSL
FF-RW	C	100		211.55	6.68	7.5	62	Ft. MSL
			System Total:	300 gpm				

Pipe Runs:

Designation	Map Length (Feet):	Hydraulic Length (Feet):	Diameter (Inches):	Flow Carried (gpm):
CF1	540	600	6	100
CF2	75	100	4	100
CF3	1180	1300	6	200
CF4	265	300	8	300
CF5	190	230	8	400
CF6	525	600	8	500
CF7	250	400	8	800
CF8	270	325	8	100
CF9	275	325	8	200
CF10	3240	3400	8	300
CF11	1500	1600	8	800
CF12	850	950	10	800

Designation	Map Length (Feet):	Hydraulic Length (Feet):	Diameter (Inches):	Flow Carried (gpm):
FF1	2225	2300	6	100
FF2	475	500	6	200
FF3	120	200	4	100
FF4	650	700	6	100
FF5	2475	2550	6	300
FF6	50	150	6	300

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW A**

Design Flow Rate:	100	gpm	13.37 cfm		0.223 cfs	
Well depth:	100	Feet				
Casing diameter	8	inch				
Screen diameter	6	PIPE SIZE				
Screen length:	20					
Slot Size:	20		assumed typical value			
Screen open area:	36.92	sq. in./ft.	renders:	738.4765 sq. in.		5.13 sq. ft.

screen approach velocity: 0.04 fps
velocity check: OK as v <= 0.1 fps

Test pump and boring data
depth to water: 30 feet 42.5 WT elev.

specific capacity: 20 gpm per ft of drawdown - assumed based on well size, low approach velocity and area geology
drawdown: 5.0 feet

Discharge piping velocity:	100 gpm	800 gpm
2 inch =	10.21 fps	81.70 fps
2.5 inch =	6.54 fps	52.29 fps
3 inch =	4.54 fps	36.31 fps
4 inch =	2.55 fps	20.42 fps
6 inch =	1.13 fps	9.08 fps
8 inch =	0.64 fps	5.11 fps
10 inch =	0.41 fps	3.27 fps
12 inch =	0.28 fps	2.27 fps

pump diameter: 4 inch

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)
C = 120

column pipe size: 2.5 inch
pump setting: 50 feet below grade

column pipe: 4.32 feet of head
gpm**1.85: 5011.872336
C**1.85: 7022.395823
dia**4.8655: 86.33305559

C = 120

suction pipe size: 3 inch
equivalent length: 0 feet

suction pipe: 0.00 feet of head
gpm**1.85: 5011.872336
C**1.85: 7022.395823
dia**4.8655: 209.6203611

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW A**

CF1 Flow Rate:	100	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	0.73	feet of head
equivalent length:	600	feet		gpm**1.85:	5011.872336	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
CF3 Flow Rate:	200	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	5.71	feet of head
equivalent length:	1300	feet		gpm**1.85:	18067.80905	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
CF4 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.69	feet of head
equivalent length:	300	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF5 Flow Rate:	400	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.90	feet of head
equivalent length:	230	feet		gpm**1.85:	65134.48505	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF6 Flow Rate:	500	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	3.54	feet of head
equivalent length:	600	feet		gpm**1.85:	98422.52624	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF7 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	5.64	feet of head
equivalent length:	400	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

TOTAL Well DISCHARGE to GAC
17.21
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW A**

CF11 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	22.55	feet of head
equivalent length:	1600	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF12 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	10	inch		**discharge pipe:**	4.52	feet of head
equivalent length:	950	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	73366.87144	

TOTAL GAC Effluent to Basin
27.07
feet of head

Pump Sizing:
Flow: 100 gpm

TDH:	(psi)	(feet)			
	15.2	35.00	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.9	4.32	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	7.5	17.21	Well discharge pipe friction	86	Grade Elev at well (Feet MSL)
	7.4	17.00	vertical lift to GAC Vessel Hdr	98	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	5	GAC Header Height above grade
	11.7	27.07	GAC Effluent pipe friction	77	Grade Elev at Basin Discharge (Feet MSL)
	-3.9	-9.00	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	67.9	156.60	FEET (specific energy)		

Electric Motor and Pump Sizing:

Flow:	100	gpm
TDH:	156.6	FEET (specific energy)
pump eff.	80%	

Energy to water:	3.95	HP
Energy to pump:	4.94	HP
Select Motor:	5	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW B**

Design Flow Rate:	100	gpm	13.37 cfm		0.223 cfs	
Well depth:	100	Feet				
Casing diameter	8	inch				
Screen diameter	6	PIPE SIZE				
Screen length:	20					
Slot Size:	20		assumed typical value			
Screen open area:	36.92	sq. in./ft.	renders:	738.4765 sq. in.		5.13 sq. ft.

screen approach velocity:	0.04	fps
velocity check:	OK	as v <= 0.1 fps

Test pump and boring data

depth to water:	30	feet	42.5	WT elev.
specific capacity:	20	gpm per ft of drawdown	- assumed based on well size, low approach velocity and area geology	
drawdown:	5.0	feet		

Discharge piping velocity:	100 gpm	800 gpm
2 inch =	10.21 fps	81.70 fps
2.5 inch =	6.54 fps	52.29 fps
3 inch =	4.54 fps	36.31 fps
4 inch =	2.55 fps	20.42 fps
6 inch =	1.13 fps	9.08 fps
8 inch =	0.64 fps	5.11 fps
10 inch =	0.41 fps	3.27 fps
12 inch =	0.28 fps	2.27 fps

pump diameter: 4 inch

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)

column pipe size:	2.5 inch	C = 120		
		column pipe:		4.32 feet of head
pump setting:	50 feet below grade		gpm**1.85:	5011.872336
			C**1.85:	7022.395823
			dia**4.8655:	86.33305559
		C = 120		
suction pipe size:	3 inch	**suction pipe:**		0.00 feet of head
equivalent length:	0 feet		gpm**1.85:	5011.872336
			C**1.85:	7022.395823
			dia**4.8655:	209.6203611

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW B**

CF2 Flow Rate:	100	GPM	C =	120		
discharge pipe size:	4	inch		**discharge pipe:**	0.88	feet of head
equivalent length:	100	feet		gpm**1.85:	5011.872336	
				C**1.85:	7022.395823	
				dia**4.8655:	849.8120556	
CF3 Flow Rate:	200	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	5.71	feet of head
equivalent length:	1300	feet		gpm**1.85:	18067.80905	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
CF4 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.69	feet of head
equivalent length:	300	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF5 Flow Rate:	400	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.90	feet of head
equivalent length:	230	feet		gpm**1.85:	65134.48505	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF6 Flow Rate:	500	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	3.54	feet of head
equivalent length:	600	feet		gpm**1.85:	98422.52624	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF7 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	5.64	feet of head
equivalent length:	400	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

TOTAL Well DISCHARGE to GAC
17.36
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW B**

CF11 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	22.55	feet of head
equivalent length:	1600	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

CF12 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	10	inch		**discharge pipe:**	4.52	feet of head
equivalent length:	950	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	73366.87144	

TOTAL GAC Effluent to Basin
27.07
feet of head

Pump Sizing:
Flow: 100 gpm

TDH:	(psi)	(feet)			
	15.2	35.00	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.9	4.32	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	7.5	17.36	Well discharge pipe friction	84	Grade Elev at well (Feet MSL)
	8.2	19.00	vertical lift to GAC Vessel Hdr	98	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	5	GAC Header Height above grade
	11.7	27.07	GAC Effluent pipe friction	77	Grade Elev at Basin Discharge (Feet MSL)
	-3.0	-7.00	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	69.7	160.74	FEET (specific energy)		

Electric Motor and Pump Sizing:

Flow:	100	gpm
TDH:	160.7	FEET (specific energy)
pump eff.	80%	

Energy to water:	4.06	HP
Energy to pump:	5.07	HP
Select Motor:	5	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW C**

Design Flow Rate:	50	gpm	6.68 cfm		0.111 cfs		
Well depth:	100	Feet					
Casing diameter	8	inch					
Screen diameter	6	PIPE SIZE					
Screen length:	20						
Slot Size:	20		assumed typical value				
Screen open area:	36.92	sq. in./ft.	renders:	738.4765	sq. in.	5.13	sq. ft.

screen approach velocity: 0.02 fps
velocity check: OK as v <= 0.1 fps

Test pump and boring data
depth to water: 30 feet 42.5 WT elev.

specific capacity: 20 gpm per ft of drawdown - assumed based on well size, low approach velocity and area geology
drawdown: 2.5 feet

Discharge piping velocity:	50 gpm	800 gpm
2 inch =	5.11 fps	81.70 fps
2.5 inch =	3.27 fps	52.29 fps
3 inch =	2.27 fps	36.31 fps
4 inch =	1.28 fps	20.42 fps
6 inch =	0.57 fps	9.08 fps
8 inch =	0.32 fps	5.11 fps
10 inch =	0.20 fps	3.27 fps
12 inch =	0.14 fps	2.27 fps

pump diameter: 4 inch

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)
C = 120

column pipe size: 2.5 inch
pump setting: 50 feet below grade

column pipe: 1.20 feet of head
gpm**1.85: 1390.255136
C**1.85: 7022.395823
dia**4.8655: 86.33305559

C = 120

suction pipe size: 3 inch
equivalent length: 0 feet

suction pipe: 0.00 feet of head
gpm**1.85: 1390.255136
C**1.85: 7022.395823
dia**4.8655: 209.6203611

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW C**

CF2 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	4	inch		**discharge pipe:**	0.00	feet of head
equivalent length:	100	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	849.8120556	
CF3 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	0.00	feet of head
equivalent length:	1300	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
CF4 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.69	feet of head
equivalent length:	300	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF5 Flow Rate:	400	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.90	feet of head
equivalent length:	230	feet		gpm**1.85:	65134.48505	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF6 Flow Rate:	500	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	3.54	feet of head
equivalent length:	600	feet		gpm**1.85:	98422.52624	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF7 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	5.64	feet of head
equivalent length:	400	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

TOTAL Well DISCHARGE
to GAC
10.77
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW C**

CF11 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch	**discharge pipe:**		22.55	feet of head
equivalent length:	1600	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF12 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	10	inch	**discharge pipe:**		4.52	feet of head
equivalent length:	950	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	73366.87144	

TOTAL GAC Effluent to Basin
27.07
feet of head

Pump Sizing:
Flow: 50 gpm

TDH:	(psi)	(feet)			
	14.1	32.50	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	0.5	1.20	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	4.7	10.77	Well discharge pipe friction	100	Grade Elev at well (Feet MSL)
	1.3	3.00	vertical lift to GAC Vessel Hdr	98	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	5	GAC Header Height above grade
	11.7	27.07	GAC Effluent pipe friction	77	Grade Elev at Basin Discharge (Feet MSL)
	-10.0	-23.00	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	50.5	116.53	FEET (specific energy)		

Electric Motor and Pump Sizing:

Flow:	50	gpm
TDH:	116.5	FEET (specific energy)
pump eff.	80%	

Energy to water:	1.47	HP
Energy to pump:	1.84	HP
Select Motor:	4	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW D**

Design Flow Rate:	100 gpm		13.37 cfm		0.223 cfs	
Well depth:	100 Feet					
Casing diameter	8 inch					
Screen diameter	6 PIPE SIZE					
Screen length:	20					
Slot Size:	20	assumed typical value				
Screen open area:	36.92 sq. in./ft.	renders:	738.4765 sq. in.		5.13 sq. ft.	

screen approach velocity: 0.04 fps
velocity check: OK as v <= 0.1 fps

Test pump and boring data
depth to water: 30 feet 42.5 WT elev.

specific capacity: 20 gpm per ft of drawdown - assumed based on well size, low approach velocity and area geology
drawdown: 5.0 feet

Discharge piping velocity:	100 gpm	800 gpm
2 inch =	10.21 fps	81.70 fps
2.5 inch =	6.54 fps	52.29 fps
3 inch =	4.54 fps	36.31 fps
4 inch =	2.55 fps	20.42 fps
6 inch =	1.13 fps	9.08 fps
8 inch =	0.64 fps	5.11 fps
10 inch =	0.41 fps	3.27 fps
12 inch =	0.28 fps	2.27 fps

pump diameter: 4 inch

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)

C = 120

column pipe size: 2.5 inch
pump setting: 50 feet below grade

column pipe: 4.32 feet of head

gpm**1.85:	5011.872336
C**1.85:	7022.395823
dia**4.8655:	86.33305559

C = 120

suction pipe size: 3 inch
equivalent length: 0 feet

suction pipe: 0.00 feet of head

gpm**1.85:	5011.872336
C**1.85:	7022.395823
dia**4.8655:	209.6203611

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW D**

CF2 Flow Rate:	0	GPM	C =	120			
discharge pipe size:	4	inch		**discharge pipe:**		0.00	feet of head
equivalent length:	100	feet			gpm**1.85:	0	
					C**1.85:	7022.395823	
					dia**4.8655:	849.8120556	
CF3 Flow Rate:	0	GPM	C =	120			
discharge pipe size:	6	inch		**discharge pipe:**		0.00	feet of head
equivalent length:	1300	feet			gpm**1.85:	0	
					C**1.85:	7022.395823	
					dia**4.8655:	6110.75552	
CF4 Flow Rate:	0	GPM	C =	120			
discharge pipe size:	8	inch		**discharge pipe:**		0.00	feet of head
equivalent length:	300	feet			gpm**1.85:	0	
					C**1.85:	7022.395823	
					dia**4.8655:	24773.3268	
CF5 Flow Rate:	400	GPM	C =	120			
discharge pipe size:	8	inch		**discharge pipe:**		0.90	feet of head
equivalent length:	230	feet			gpm**1.85:	65134.48505	
					C**1.85:	7022.395823	
					dia**4.8655:	24773.3268	
CF6 Flow Rate:	500	GPM	C =	120			
discharge pipe size:	8	inch		**discharge pipe:**		3.54	feet of head
equivalent length:	600	feet			gpm**1.85:	98422.52624	
					C**1.85:	7022.395823	
					dia**4.8655:	24773.3268	
CF7 Flow Rate:	800	GPM	C =	120			
discharge pipe size:	8	inch		**discharge pipe:**		5.64	feet of head
equivalent length:	400	feet			gpm**1.85:	234809.9391	
					C**1.85:	7022.395823	
					dia**4.8655:	24773.3268	

TOTAL Well DISCHARGE
to GAC
10.08
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW D**

CF11 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch	**discharge pipe:**		22.55	feet of head
equivalent length:	1600	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

CF12 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	10	inch	**discharge pipe:**		4.52	feet of head
equivalent length:	950	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	73366.87144	

TOTAL GAC Effluent to Basin
27.07
feet of head

Pump Sizing:
Flow: 100 gpm

TDH:	(psi)	(feet)			
	15.2	35.00	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.9	4.32	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	4.4	10.08	Well discharge pipe friction	100	Grade Elev at well (Feet MSL)
	1.3	3.00	vertical lift to GAC Vessel Hdr	98	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	5	GAC Header Height above grade
	11.7	27.07	GAC Effluent pipe friction	77	Grade Elev at Basin Discharge (Feet MSL)
	-10.0	-23.00	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	52.7	121.46	FEET (specific energy)		

Electric Motor and Pump Sizing:
Flow: 100 gpm
TDH: 121.5 FEET (specific energy)
pump eff. 80%

Energy to water: 3.07 HP
Energy to pump: 3.83 HP
Select Motor: 4 HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW E**

Design Flow Rate:	50	gpm	6.68 cfm	0.111 cfs		
Well depth:	100	Feet				
Casing diameter	8	inch				
Screen diameter	6	PIPE SIZE				
Screen length:	20					
Slot Size:	20		assumed typical value			
Screen open area:	36.92	sq. in./ft.	renders:	738.4765 sq. in.		5.13 sq. ft.

screen approach velocity: 0.02 fps
velocity check: OK as v <= 0.1 fps

Test pump and boring data
depth to water: 30 feet 42.5 WT elev.

specific capacity: 20 gpm per ft of drawdown - assumed based on well size, low approach velocity and area geology
drawdown: 2.5 feet

Discharge piping velocity:	50 gpm	800 gpm
2 inch =	5.11 fps	81.70 fps
2.5 inch =	3.27 fps	52.29 fps
3 inch =	2.27 fps	36.31 fps
4 inch =	1.28 fps	20.42 fps
6 inch =	0.57 fps	9.08 fps
8 inch =	0.32 fps	5.11 fps
10 inch =	0.20 fps	3.27 fps
12 inch =	0.14 fps	2.27 fps

pump diameter: 4 inch

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)
C = 120

column pipe size: 2.5 inch
pump setting: 50 feet below grade

column pipe: 1.20 feet of head
gpm**1.85: 1390.255136
C**1.85: 7022.395823
dia**4.8655: 86.33305559

C = 120

suction pipe size: 3 inch
equivalent length: 0 feet

suction pipe: 0.00 feet of head
gpm**1.85: 1390.255136
C**1.85: 7022.395823
dia**4.8655: 209.6203611

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW E**

CF2 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	4	inch		**discharge pipe:**	0.00	feet of head
equivalent length:	100	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	849.8120556	
CF3 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	0.00	feet of head
equivalent length:	1300	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
CF4 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.00	feet of head
equivalent length:	300	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF5 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.00	feet of head
equivalent length:	230	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF6 Flow Rate:	500	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	3.54	feet of head
equivalent length:	600	feet		gpm**1.85:	98422.52624	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF7 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	5.64	feet of head
equivalent length:	400	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

TOTAL Well DISCHARGE to GAC
9.18
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW E**

CF11 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	22.55	feet of head
equivalent length:	1600	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

CF12 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	10	inch		**discharge pipe:**	4.52	feet of head
equivalent length:	950	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	73366.87144	

TOTAL GAC Effluent to Basin
27.07
feet of head

Pump Sizing:

Flow: 50 gpm

TDH:	(psi)	(feet)			
	14.1	32.50	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	0.5	1.20	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	4.0	9.18	Well discharge pipe friction	100	Grade Elev at well (Feet MSL)
	1.3	3.00	vertical lift to GAC Vessel Hdr	98	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	5	GAC Header Height above grade
	11.7	27.07	GAC Effluent pipe friction	77	Grade Elev at Basin Discharge (Feet MSL)
	-10.0	-23.00	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	49.8	114.94	FEET (specific energy)		

Electric Motor and Pump Sizing:

Flow:	50	gpm
TDH:	114.9	FEET (specific energy)
pump eff.	80%	

Energy to water:	1.45	HP
Energy to pump:	1.81	HP
Select Motor:	4	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW F**

Design Flow Rate:	75	gpm	10.03	cfm	0.167	cfs	
Well depth:	100	Feet					
Casing diameter	8	inch					
Screen diameter	6	PIPE SIZE					
Screen length:	20						
Slot Size:	20		assumed typical value				
Screen open area:	36.92	sq. in./ft.	renders:	738.4765	sq. in.	5.13	sq. ft.

screen approach velocity:	0.03	fps
velocity check:	OK as v <= 0.1 fps	

Test pump and boring data

depth to water:	30	feet	42.5	WT elev.
specific capacity:	20	gpm per ft of drawdown - assumed based on well size, low approach velocity and area geology		
drawdown:	3.8	feet		

Discharge piping velocity:	75 gpm	800 gpm
2 inch =	7.66 fps	81.70 fps
2.5 inch =	4.90 fps	52.29 fps
3 inch =	3.40 fps	36.31 fps
4 inch =	1.91 fps	20.42 fps
6 inch =	0.85 fps	9.08 fps
8 inch =	0.48 fps	5.11 fps
10 inch =	0.31 fps	3.27 fps
12 inch =	0.21 fps	2.27 fps

pump diameter: 4 inch

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)

column pipe size: 2.5 inch	C =	120		
pump setting: 50 feet below grade	**column pipe:**		2.53	feet of head
		gpm**1.85:	2943.495236	
		C**1.85:	7022.395823	
		dia**4.8655:	86.33305559	

	C =	120		
suction pipe size: 3 inch	**suction pipe:**		0.00	feet of head
equivalent length: 0 feet		gpm**1.85:	2943.495236	
		C**1.85:	7022.395823	
		dia**4.8655:	209.6203611	

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW F**

CF8 Flow Rate:	100	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.10	feet of head
equivalent length:	325	feet		gpm**1.85:	5011.872336	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF9 Flow Rate:	200	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.35	feet of head
equivalent length:	325	feet		gpm**1.85:	18067.80905	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF10 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	7.81	feet of head
equivalent length:	3400	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF7 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	5.64	feet of head
equivalent length:	400	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

TOTAL Well DISCHARGE to GAC
13.89
feet of head

CF11 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	22.55	feet of head
equivalent length:	1600	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF12 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	10	inch		**discharge pipe:**	4.52	feet of head
equivalent length:	950	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	73366.87144	

TOTAL GAC Effluent to Basin
27.07
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW F**

Pump Sizing:

	Flow:	75	gpm

	(psi)	(feet)			
TDH:					
	14.6	33.75	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.1	2.53	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	6.0	13.89	Well discharge pipe friction	90	Grade Elev at well (Feet MSL)
	-2.6	-6.00	vertical lift to GAC Vessel Hdr	74	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	10	GAC Header Height above grade
	11.7	27.07	GAC Effluent pipe friction	77	Grade Elev at Basin Discharge (Feet MSL)
	-5.6	-13.00	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	53.4	123.24	FEET (specific energy)		

Electric Motor and Pump Sizing:

	Flow:	75	gpm
	TDH:	123.2	FEET (specific energy)
	pump eff.	80%	

Energy to water:	2.33	HP
Energy to pump:	2.92	HP
Select Motor:	4	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW G**

Design Flow Rate:	100	gpm	13.37	cfm	0.223	cfs
Well depth:	100	Feet				
Casing diameter	8	inch				
Screen diameter	6	PIPE SIZE				
Screen length:	20					
Slot Size:	20		assumed typical value			
Screen open area:	36.92	sq. in./ft.	renders:	738.4765 sq. in.	5.13	sq. ft.

screen approach velocity: 0.04 fps
velocity check: OK as v <= 0.1 fps

Test pump and boring data
depth to water: 30 feet 42.5 WT elev.

specific capacity: 20 gpm per ft of drawdown - assumed based on well size, low approach velocity and area geology
drawdown: 5.0 feet

Discharge piping velocity:	100 gpm	800 gpm
2 inch =	10.21 fps	81.70 fps
2.5 inch =	6.54 fps	52.29 fps
3 inch =	4.54 fps	36.31 fps
4 inch =	2.55 fps	20.42 fps
6 inch =	1.13 fps	9.08 fps
8 inch =	0.64 fps	5.11 fps
10 inch =	0.41 fps	3.27 fps
12 inch =	0.28 fps	2.27 fps

pump diameter: 4 inch

column pipe size: 2.5 inch
pump setting: 50 feet below grade

suction pipe size: 3 inch
equivalent length: 0 feet

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)

C = 120

column pipe: 4.32 feet of head
gpm**1.85: 5011.872336
C**1.85: 7022.395823
dia**4.8655: 86.33305559

C = 120

suction pipe: 0.00 feet of head
gpm**1.85: 5011.872336
C**1.85: 7022.395823
dia**4.8655: 209.6203611

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW G**

CF8 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.00	feet of head
equivalent length:	325	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF9 Flow Rate:	200	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	0.35	feet of head
equivalent length:	325	feet		gpm**1.85:	18067.80905	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF10 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	7.81	feet of head
equivalent length:	3400	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF7 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	5.64	feet of head
equivalent length:	400	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

TOTAL Well DISCHARGE to GAC
13.79
feet of head

CF11 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch		**discharge pipe:**	22.55	feet of head
equivalent length:	1600	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF12 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	10	inch		**discharge pipe:**	4.52	feet of head
equivalent length:	950	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	73366.87144	

TOTAL GAC Effluent to Basin
27.07
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW G**

Pump Sizing:

Flow:		100	gpm

	(psi)	(feet)			
TDH:	(psi)	(feet)			
	15.2	35.00	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.9	4.32	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	6.0	13.79	Well discharge pipe friction	96	Grade Elev at well (Feet MSL)
	-5.2	-12.00	vertical lift to GAC Vessel Hdr	74	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	10	GAC Header Height above grade
	11.7	27.07	GAC Effluent pipe friction	77	Grade Elev at Basin Discharge (Feet MSL)
	-8.2	-19.00	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	49.5	114.18	FEET (specific energy)		

Electric Motor and Pump Sizing:

Flow:	100	gpm
TDH:	114.2	FEET (specific energy)
pump eff.	80%	

Energy to water:	2.88	HP
Energy to pump:	3.60	HP
Select Motor:	4	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW H**

Design Flow Rate:	75 gpm		10.03 cfm		0.167 cfs	
Well depth:	100 Feet					
Casing diameter	8 inch					
Screen diameter	6 PIPE SIZE					
Screen length:	20					
Slot Size:	20	assumed typical value				
Screen open area:	36.92 sq. in./ft.	renders:	738.4765 sq. in.			5.13 sq. ft.

screen approach velocity: 0.03 fps
velocity check: OK as v <= 0.1 fps

Test pump and boring data
depth to water: 30 feet 42.5 WT elev.

specific capacity: 20 gpm per ft of drawdown - assumed based on well size, low approach velocity and area geology
drawdown: 3.8 feet

Discharge piping velocity:	75 gpm	800 gpm
2 inch =	7.66 fps	81.70 fps
2.5 inch =	4.90 fps	52.29 fps
3 inch =	3.40 fps	36.31 fps
4 inch =	1.91 fps	20.42 fps
6 inch =	0.85 fps	9.08 fps
8 inch =	0.48 fps	5.11 fps
10 inch =	0.31 fps	3.27 fps
12 inch =	0.21 fps	2.27 fps

pump diameter: 4 inch

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)

column pipe size:	2.5 inch	C = 120		
		column pipe:		2.53 feet of head
pump setting:	50 feet below grade		gpm**1.85:	2943.495236
			C**1.85:	7022.395823
			dia**4.8655:	86.33305559
		C = 120		
suction pipe size:	3 inch	**suction pipe:**		0.00 feet of head
equivalent length:	0 feet		gpm**1.85:	2943.495236
			C**1.85:	7022.395823
			dia**4.8655:	209.6203611

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW H**

CF8 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	8	inch	**discharge pipe:**		0.00	feet of head
equivalent length:	325	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF9 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	8	inch	**discharge pipe:**		0.00	feet of head
equivalent length:	325	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF10 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	8	inch	**discharge pipe:**		7.81	feet of head
equivalent length:	3400	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF7 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch	**discharge pipe:**		5.64	feet of head
equivalent length:	400	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	

TOTAL Well DISCHARGE to GAC
13.44
feet of head

CF11 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	8	inch	**discharge pipe:**		22.55	feet of head
equivalent length:	1600	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	24773.3268	
CF12 Flow Rate:	800	GPM	C =	120		
discharge pipe size:	10	inch	**discharge pipe:**		4.52	feet of head
equivalent length:	950	feet		gpm**1.85:	234809.9391	
				C**1.85:	7022.395823	
				dia**4.8655:	73366.87144	

TOTAL GAC Effluent to Basin
27.07
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **CF-RW H**

Pump Sizing:

	Flow:	75	gpm

	(psi)	(feet)			
TDH:					
	14.6	33.75	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.1	2.53	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	5.8	13.44	Well discharge pipe friction	98	Grade Elev at well (Feet MSL)
	-6.1	-14.00	vertical lift to GAC Vessel Hdr	74	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	10	GAC Header Height above grade
	11.7	27.07	GAC Effluent pipe friction	77	Grade Elev at Basin Discharge (Feet MSL)
	-9.1	-21.00	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	46.3	106.79	FEET (specific energy)		

Electric Motor and Pump Sizing:

	Flow:	75	gpm
	TDH:	106.8	FEET (specific energy)
	pump eff.	80%	

Energy to water:	2.02	HP
Energy to pump:	2.53	HP
Select Motor:	4	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : FF-RW A

Design Flow Rate:	100	gpm		13.37	cfm	0.223	cfs
Well depth:	100	Feet					
Casing diameter	8	inch					
Screen diameter	6	PIPE SIZE					
Screen length:	20						
Slot Size:	20		assumed typical value				
Screen open area:	36.92	sq. in./ft.	renders:	738.4765	sq. in.	5.13	sq. ft.

screen approach velocity: 0.04 fps
velocity check: OK as v <= 0.1 fps

Test pump and boring data
depth to water: 30 feet 42.5 WT elev.

specific capacity: 20 gpm per ft of drawdown - assumed based on well size, low approach velocity and area geology
drawdown: 5.0 feet

Discharge piping velocity:	100 gpm	300 gpm
2 inch =	10.21 fps	30.64 fps
2.5 inch =	6.54 fps	19.61 fps
3 inch =	4.54 fps	13.62 fps
4 inch =	2.55 fps	7.66 fps
6 inch =	1.13 fps	3.40 fps
8 inch =	0.64 fps	1.91 fps
10 inch =	0.41 fps	1.23 fps
12 inch =	0.28 fps	0.85 fps

pump diameter: 4 inch

column pipe size: 2.5 inch
pump setting: 50 feet below grade

suction pipe size: 3 inch
equivalent length: 0 feet

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)

C = 120

column pipe: 4.32 feet of head
gpm**1.85: 5011.872336
C**1.85: 7022.395823
dia**4.8655: 86.33305559

C = 120

suction pipe: 0.00 feet of head
gpm**1.85: 5011.872336
C**1.85: 7022.395823
dia**4.8655: 209.6203611

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **FF-RW A**

FF1 Flow Rate:	100	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	2.80	feet of head
equivalent length:	2300	feet		gpm**1.85:	5011.872336	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
FF2 Flow Rate:	200	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	2.20	feet of head
equivalent length:	500	feet		gpm**1.85:	18067.80905	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
FF5 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	23.73	feet of head
equivalent length:	2550	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	

TOTAL Well DISCHARGE to GAC
28.73
feet of head

FF6 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	1.40	feet of head
equivalent length:	150	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	

TOTAL GAC Effluent to Basin
1.40
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **FF-RW A**

Pump Sizing:

Flow:		100	gpm		
TDH:	(psi)	(feet)			
	15.2	35.00	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.9	4.32	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	12.5	28.73	Well discharge pipe friction	72	Grade Elev at well (Feet MSL)
	17.8	41.00	vertical lift to GAC Vessel Hdr	98	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	15	GAC Header Height above grade
	0.6	1.40	GAC Effluent pipe friction	90.5	Grade Elev at Basin Discharge (Feet MSL)
	8.0	18.50	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	84.1	193.95	FEET (specific energy)		

Electric Motor and Pump Sizing:

Flow:	100	gpm
TDH:	193.9	FEET (specific energy)
pump eff.	80%	
Energy to water:	4.90	HP
Energy to pump:	6.12	HP
Select Motor:	7.5	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **FF-RW B**

Design Flow Rate:	100	gpm	13.37	cfm	0.223	cfs
Well depth:	100	Feet				
Casing diameter	8	inch				
Screen diameter	6	PIPE SIZE				
Screen length:	20					
Slot Size:	20		assumed typical value			
Screen open area:	36.92	sq. in./ft.	renders: 738.4765	sq. in.	5.13	sq. ft.

screen approach velocity:	0.04	fps
velocity check:	OK	as v <= 0.1 fps

Test pump and boring data

depth to water:	30	feet	42.5	WT elev.

specific capacity:	20	gpm per ft of drawdown	- assumed based on well size, low approach velocity and area geology
drawdown:	5.0	feet	

Discharge piping velocity:	100 gpm	300 gpm
2 inch =	10.21 fps	30.64 fps
2.5 inch =	6.54 fps	19.61 fps
3 inch =	4.54 fps	13.62 fps
4 inch =	2.55 fps	7.66 fps
6 inch =	1.13 fps	3.40 fps
8 inch =	0.64 fps	1.91 fps
10 inch =	0.41 fps	1.23 fps
12 inch =	0.28 fps	0.85 fps

pump diameter: 4 inch

column pipe size: 2.5 inch
pump setting: 50 feet below grade

suction pipe size: 3 inch
equivalent length: 0 feet

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)

C = 120

column pipe:	4.32	feet of head
gpm**1.85:	5011.872336	
C**1.85:	7022.395823	
dia**4.8655:	86.33305559	

C = 120

suction pipe:	0.00	feet of head
gpm**1.85:	5011.872336	
C**1.85:	7022.395823	
dia**4.8655:	209.6203611	

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **FF-RW B**

FF1 Flow Rate:	0	GPM	C =	120		
discharge pipe size:	6	inch	**discharge pipe:**		0.00	feet of head
equivalent length:	2300	feet		gpm**1.85:	0	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
FF2 Flow Rate:	200	GPM	C =	120		
discharge pipe size:	6	inch	**discharge pipe:**		2.20	feet of head
equivalent length:	500	feet		gpm**1.85:	18067.80905	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
FF5 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	6	inch	**discharge pipe:**		23.73	feet of head
equivalent length:	2550	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	

TOTAL Well DISCHARGE to GAC
25.93
feet of head

FF6 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	6	inch	**discharge pipe:**		1.40	feet of head
equivalent length:	150	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	

TOTAL GAC Effluent to Basin
1.40
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **FF-RW B**

Pump Sizing:

Flow:	100	gpm

TDH:	(psi)	(feet)			
	15.2	35.00	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.9	4.32	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	11.2	25.93	Well discharge pipe friction	66	Grade Elev at well (Feet MSL)
	20.4	47.00	vertical lift to GAC Vessel Hdr	98	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	15	GAC Header Height above grade
	0.6	1.40	GAC Effluent pipe friction	90.5	Grade Elev at Basin Discharge (Feet MSL)
	10.6	24.50	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	88.1	203.14	FEET (specific energy)		

Electric Motor and Pump Sizing:

Flow:	100	gpm
TDH:	203.1	FEET (specific energy)
pump eff.	80%	

Energy to water:	5.13	HP
Energy to pump:	6.41	HP
Select Motor:	7.5	HP

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **FF-RW C**

Design Flow Rate:	100	gpm		13.37	cfm	0.223	cfs	
Well depth:	100	Feet						
Casing diameter	8	inch						
Screen diameter	6	PIPE SIZE						
Screen length:	20							
Slot Size:	20		assumed typical value					
Screen open area:	36.92	sq. in./ft.	renders:	738.4765	sq. in.		5.13	sq. ft.

screen approach velocity:	0.04	fps
velocity check:	OK	as v <= 0.1 fps

Test pump and boring data

depth to water:	30	feet	42.5	WT elev.
specific capacity:	20	gpm per ft of drawdown	- assumed based on well size, low approach velocity and area geology	
drawdown:	5.0	feet		

Discharge piping velocity:	100	gpm	300	gpm
2 inch =	10.21	fps	30.64	fps
2.5 inch =	6.54	fps	19.61	fps
3 inch =	4.54	fps	13.62	fps
4 inch =	2.55	fps	7.66	fps
6 inch =	1.13	fps	3.40	fps
8 inch =	0.64	fps	1.91	fps
10 inch =	0.41	fps	1.23	fps
12 inch =	0.28	fps	0.85	fps

pump diameter:	4	inch
column pipe size:	2.5	inch
pump setting:	50	feet below grade
suction pipe size:	3	inch
equivalent length:	0	feet

Pipe Friction:
Hazen-Williams (turbulent flow, temp. approx 55 F)

C =	120		
column pipe:		4.32	feet of head
	gpm**1.85:	5011.872336	
	C**1.85:	7022.395823	
	dia**4.8655:	86.33305559	
C =	120		
suction pipe:		0.00	feet of head
	gpm**1.85:	5011.872336	
	C**1.85:	7022.395823	
	dia**4.8655:	209.6203611	

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **FF-RW C**

FF3 Flow Rate:	100	GPM	C =	120		
discharge pipe size:	4	inch		**discharge pipe:**	1.75	feet of head
equivalent length:	200	feet		gpm**1.85:	5011.872336	
				C**1.85:	7022.395823	
				dia**4.8655:	849.8120556	
FF4 Flow Rate:	100	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	0.85	feet of head
equivalent length:	700	feet		gpm**1.85:	5011.872336	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	
FF5 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	23.73	feet of head
equivalent length:	2550	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	

TOTAL Well DISCHARGE to GAC
26.34
feet of head

FF6 Flow Rate:	300	GPM	C =	120		
discharge pipe size:	6	inch		**discharge pipe:**	1.40	feet of head
equivalent length:	150	feet		gpm**1.85:	38253.77695	
				C**1.85:	7022.395823	
				dia**4.8655:	6110.75552	

TOTAL GAC Effluent to Basin
1.40
feet of head

Well Sizing
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Project Parameters and Equipment Sizing

Remediation Well : **FF-RW C**

Pump Sizing:

Flow:		100	gpm

TDH:	(psi)	(feet)			
	15.2	35.00	vertical lift at well to grade		
	0.0	0.00	hydraulic interference		
	1.9	4.32	column friction		
	0.0	0.00	suction pipe friction		
	8.7	20.00	meter & valve losses		
	11.4	26.34	Well discharge pipe friction	62	Grade Elev at well (Feet MSL)
	22.1	51.00	vertical lift to GAC Vessel Hdr	98	Grade Elev at GAC (Feet MSL)
	10.8	25.00	Filter Backpressure	15	GAC Header Height above grade
	0.6	1.40	GAC Effluent pipe friction	90.5	Grade Elev at Basin Discharge (Feet MSL)
	12.4	28.50	Net Lift Grade to Basin		
	8.7	20.00	misc. losses		
Total	91.7	211.55	FEET (specific energy)		

Electric Motor and Pump Sizing:

Flow:	100	gpm
TDH:	211.6	FEET (specific energy)
pump eff.	80%	

Energy to water:	5.34	HP
Energy to pump:	6.68	HP
Select Motor:	7.5	HP

GAC Filter Vessels
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

The configuration of the filter vessel and underdrain system is important to understand observations of contaminant "break through" and sampling from intermediate Points of the GAC media bed. Large cone-bottom vessels such as a Calgon Model 10 have numerous underdrain screens located at a variety of depths within the bed.

The Calgon Model 10 cone bottom has 80 small screens located along 6 concentric circles

Circle Diameter (Feet)	Number of Screens	% of Total
7	22	27.5%
6	16	20.0%
5	16	20.0%
4	12	15.0%
3	9	11.3%
2	5	6.3%
	80	100.0%

The underdrain screens are arrayed on an internal cone having a 10 foot diameter and 45 degree angle. The volume of this cone is given as:

V = pi * r * r * h/3 so for h = r = 5 feet results in a volume of
5 5

V = 130.90 Cubic Feet = 979.2 gallons

The volume of the filter vessel above the cone bottom is based on a 10 foot diameter circle. The Model 10 has a straight shell height of 14 feet between the dished heads but a poprtion of this remains as empty head space for bed expansion during backwashing and for flow distribution above the media bed during filtration operations. Note that the cone bottom overlaps the srraight sheel by about 30 inches so the straight shell height above the cone is about 11.5 feet.

Volume per foot of straight shell:

V = 78.54 Cubic Feet = 587.5 gallons

The nominal full load of a Model 10 Filter vessel is 20,000 pounds of GAC. There are several different choices of GAC that can have different densities and therefore different inplace volumes.

Manufacturer	Type	Apparent Density (g/cc)	Apparent Density (lb/ft3)	Volume / 20K pounds (Ft3)	Volume Above Cone (Ft3)	Depth Above Cone (Ft)	Cone Volume/ Total Volume
				20,000.00			
Calgon	F300	0.560	34.96	572.1	441.19	5.62	22.88%
Calgon	F300 M	0.580	36.21	552.4	421.46	5.37	23.70%
Calgon	F400	0.540	33.71	593.3	462.38	5.89	22.06%
Calgon	F400 M	0.540	33.71	593.3	462.38	5.89	22.06%
Calgon	F600	0.620	38.71	516.7	385.83	4.91	25.33%

Effluent sampling data must be evaluated with consideration that about 20% of the total GAC volume is loctaed below the highest underdrain screen elevation. It is also likely that the flow rate through the highest underdrain screens will be somewhat greater than through the lowest screens. The net effect of this is expected to be a slower "break through" curve of contaminants in the effluent flow.

The pressure drop across the GAC bed is a function of the hydraulic loading rate and the particle size distribution of the particular GAC media selected. Pressure Drop curves are generally expressed as inches of water column per foot of bed depth and plotted versus the hydraulic loading rate as GPM per square foot.

Vessel Diameter: 10 Feet X-Sect Area = 78.54 Square Feet Water Temp: 55 Deg. F.

The curves provided for F-600 and F-400 M are essentailly identical and contribute to the following:

Flow Rate (GPM)	Loading Rate (GPM/Ft2)	Pressure Drop (Inch w.c./ Ft of bed)	Avg. Bed Depth (Feet)	Total Pressure Drop (Media Only) (Inch W.C.)	Total Pressure Drop (Media Only) (Feet W.C.)	Total Pressure Drop (Media Only) (PSI)
100	1.27	1.5	7	10.5	0.88	0.38
200	2.55	2.5	7	17.5	1.46	0.63
300	3.82	3.5	7	24.5	2.04	0.89
400	5.09	5	7	35	2.92	1.26
500	6.37	6	7	42	3.50	1.52
600	7.64	7.7	7	53.9	4.49	1.95
700	8.91	9.2	7	64.4	5.37	2.33
750	9.55	10	7	70	5.83	2.53

GAC Filter Vessels
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

The curves provided for F-300 contribute to the following:

Flow Rate (GPM)	Loading Rate (GPM/Ft2)	Pressure Drop (Inch w.c./ Ft of bed)	Avg. Bed Depth (Feet)	Total Pressure Drop (Media Only) (Inch W.C.)	Total Pressure Drop (Media Only) (Feet W.C.)	Total Pressure Drop (Media Only) (PSI)
100	1.27	0.7	7	4.9	0.41	0.18
200	2.55	1.5	7	10.5	0.88	0.38
300	3.82	2	7	14	1.17	0.51
400	5.09	2.7	7	18.9	1.58	0.68
500	6.37	3.3	7	23.1	1.93	0.83
600	7.64	4.1	7	28.7	2.39	1.04
700	8.91	5.1	7	35.7	2.98	1.29
750	9.55	5.7	7	39.9	3.33	1.44

USEPA GAC Isotherm Data
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

The USEPA web site contains references and a summary of Isotherm data for liquid phase GAC filtration.

The rate of carbon exhaustion through contaminant loading to a GAC filter can be predicted utilizing the Freundlich adsorption isotherm and field experience. Large cone-bottom vessels such as a Calgon Model 10 can achieve up to 70% of the Freundlich predicted capacity when placed in continuous use and not exposed to frequent venting.
The following analysis assumes relatively low contaminant levels such that competition between compounds for reaction sites can be ignored

The Freundlich isotherm is expressed as: (Co - Cf) / M = K (Cf) **1/n
where : Co = contaminant concentration of the influent
Cf = contaminant concentration of the effluent
M = Total mass of the carbon
K and 1/n = empirical constants unique to the contaminants and carbon

The adsorptivity is estimated at saturation by setting Cf = Co yielding the following form:
Freundlich Adsorptivity = K * Co** 1/n , where Co = Cf [mg/l]

The rate of carbon consumption is estimated as follows:
pounds carbon / million gal. treated = Co [ug/l] / 1000 [ug/mg] / Freundlich Adsorptivity [mg/gram carbon] / 453.59 [gm/lb] * 3,785,000 [liter/million gallons]

Carbon Chain Length	Contaminants: Abbreviation	Freundlich Parameters (Filtrasorb 400) K (mg/g) (L/mg)	1/n	Co [mg/l]	Freundlich Adsorptivity [g contam/100 g GAC]	Freundlich GAC Consumption [lb/mil. gal treated]	Predicted GAC Consumption [lb/mil. gal treated]	
4	PFBA			0.000175				
4	PFBS	113	0.98	0.000223	0.0000	5.4	7.8	
	PFBS	256	0.92	0.000223	0.0002	1.0	1.4	
	PFBS	0.997	3.13	0.000223	0.0000	123,258,788,804,603,000	176,083,984,006,575,000	ignore
	PFBS	468	2.17	0.000223	0.0000	108,053,756	154,362,509	ignore
5	PFPeA			0.000127				
5	PFPeS			0.000626				
6	PFHxA	39400	1.45	0.000564	0.0000	13.7	19.6	
	PFHxA	48400	1.49	0.000564	0.0000	19.9	28.4	
6	PFHxS	21400	1.52	0.00371	0.0001	26.0	37.1	
	PFHxS	9290	1.72	0.00371	0.0000	730.2	1043.1	
7	PFHpA			0.000072				
7	PFHpS			0.000023				
8	PFOA	14.317	0.2504	0.000144	0.2771	0.0	0.0	**considered most reliable data**
	PFOA	0.1	0.51	0.000144	0.0000	3.7	5.3	
	PFOA	11.8	2.26	0.000144	0.0000	29,510,982,264	42,158,546,092	ignore
	PFOA	49.3	0.369	0.000144	0.1473	0.0	0.0	
	PFOA	1.21	0.89	0.000144	0.0000	121.9	174.2	modified F400
	PFOA	9.52	1.15	0.000144	0.0000	931.1	1330.2	modified F400
8	PFOS	25.9	0.9	0.00298	0.0003	9.0	12.9	
	PFOS	60.9	3.46	0.00298	0.0000	537,295,384,873,328	767,564,835,533,326	ignore
	PFOS	28.4	0.45	0.00298	0.0926	0.0268	0.0384	
	PFOS	165	1.72	0.00298	0.0000	48,137	68,768	
	PFOS	54.5	0.307	0.00298	1.0964	0.0	0.0	
	PFOS	0.05	0.63	0.00298	0.0000	151	215	modified F400
	PFOS	0.21	0.66	0.00298	0.0000	52.5	75.0	modified F400
8	PFOSA			0.00033				
8 + 1	8 + 1 Acid			0				
8 + 2	8 + 2 Acid			0				
9	PFNA			0.00004				
9	PFNS			0.0000026				
10	PFDA			0				
10	PFDS			0				
11	PFUDA			0				
12	PFDoA			0				
13	PFTrDA			0				
14	PFTeDA			0				
			Total:	0.032560	mg/L			

Conclusion: PFHxS governs, (the consumption figures are not cumulative). Assume GAC per pound cost of
$ 1.85 including handling and reactivation, yields a treatment cost of
$ 0.00 per thousand gallons treated.

Flow rate = 1200 GPM results in GAC consumption of 0 pounds per day

Filter run length based on 40,000 pound filtration system GAC capacity = 37372778.05 days.

Hourly GAC cost for 1,200 gpm continuous flow = $ 0.00
Annual GAC cost for 1,200 gpm continuous flow = $ 0.72

The calculations are based on use of Coal based Filtrasorb 400 AW (Acid Washed)
References:
1 EPA web site
https://oaspub.epa.gov/tdb/pages/contaminantProcess/contaminantProcessDetails.do
Downloaded: 9/13/2018

SCWA ACT Data
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

The Suffolk County Water Authority (SCWA) provided data for liquid phase GAC filtration of wells containing a variety fo PFCs. This data includes both filter influent and effluent data as well as Accelerated Columns Test (ACT) data performed in conjunction with the University of North Carolina.

The rate of carbon exhaustion through contaminant loading to a GAC filter can be predicted utilizing the Freundlich adsorption isotherm and field experience. Large cone-bottom vessels such as a Calgon Model 10 can achieve up to 70% of the Freundlich predicted capacity when placed in continuous use and not exposed to frequent venting.
The following analysis assumes relatively low contaminant levels such that competition between compounds for reaction sites can be ignored

The Freundlich isotherm is expressed as: (Co - Cf) / M = K (Cf) **1/n
where : Co = contaminant concentration of the influent
Cf = contaminant concentration of the effluent
M = Total mass of the carbon
K and 1/n = empirical constants unique to the contaminants and carbon

The adsorptivity is estimated at saturation by setting Cf = Co yielding the following form:
Freundlich Adsorptivity = K * Co** 1/n , where Co = Cf [mg/l]

The rate of carbon consumption is estimated as follows:
pounds carbon / million gal. treated = Co [ug/l] / 1000 [ug/mg] / Freundlich Adsorptivity [mg/gram carbon] / 453.59 [gm/lb] * 3,785,000 [liter/million gallons]

Carbon Chain Length	Contaminants: Abbreviation	Freundlich Parameters (Filtrasorb 400) K	1/n	Co [mg/l]	Freundlich Adsorptivity [g contam/100 g GAC]	Freundlich GAC Consumption [lb/mil. gal treated]	Predicted GAC Consumption [lb/mil. gal treated]	SCWA ACT Predicted GAC Consumption [lb/mil. gal treated]
4	PFBA	425	1.3	0.000023	0.00000004996	384.145	548.779	550
4	PFBS							
5	PFPeA	205	1.2	0.000047	0.00000032982	118.913	169.876	170
5	PFPeS							
6	PFHxA	150	1.15	0.000055	0.00000067222	68.274	97.535	100
6	PFHxS							
7	PFHpA	2.5	0.9	0.00004	0.00000054928	60.767	86.810	<90
7	PFHpS							
8	PFOA	14.317	0.2504	0.000058	0.22070612945	0.00022	0.00031	**considered most reliable data**
	PFOA	0.02	0.6	0.000058	0.00000091010	53.179	75.971	<90
8	PFOS							
8	PFOSA							
8 + 1	8 + 1 Acid							
8 + 2	8 + 2 Acid							
9	PFNA							
9	PFNS							
10	PFDA							
10	PFDS							
11	PFUDA							
12	PFDoA							
13	PFTrDA							
14	PFTeDA							
			Total:	0.0003	mg/L			

Conclusion: PFHxS governs, (the consumption figures are not cumulative). Assume GAC per pound cost of
$ 1.85 including handling and reactivation, yields a treatment cost of
$ 1.02 per thousand gallons treated.

Flow rate = 1200 GPM results in GAC consumption of 0 pounds per day

Filter run length based on 40,000 pound filtration system GAC capacity = 73892146.35 days.

Hourly GAC cost for 1,200 gpm continuous flow = $ 0.00
Annual GAC cost for 1,200 gpm continuous flow = $ 0.37

The calculations are based on use of Coal based Filtrasorb 400 AW (Acid Washed)

References:
1 Calgon Carbon Corp.

Current Fire House GAC Consumption
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

GAC consumption for the treatment system is predicted based on projections of well flow rates, influent concentrations and dilution factors.

The rate of carbon exhaustion through contaminant loading to a GAC filter can be predicted utilizing the Freundlich adsorption isotherm and field experience. Large cone-bottom vessels such as a Calgon Model 10 can achieve up to 70% of the Freundlich predicted capacity when placed in continuous use and not exposed to frequent venting.
The following analysis assumes relatively low contaminant levels such that competition between compounds for reaction sites can be ignored

The Freundlich isotherm is expressed as: (Co - Cf) / M = K (Cf) **1/n
where : Co = contaminant concentration of the influent
Cf = contaminant concentration of the effluent
M = Total mass of the carbon
K and 1/n = empirical constants unique to the contaminants and carbon

The adsorptivity is estimated at saturation by setting Cf = Co yielding the following form:
Freundlich Adsorptivity = K * Co** 1/n , where Co = Cf [mg/l]

The rate of carbon consumption is estimated as follows:
pounds carbon / million gal. treated = Co [ug/l] / 1000 [ug/mg] / Freundlich Adsorptivity [mg/gram carbon] / 453.59 [gm/lb] * 3,785,000 [liter/million gallons]

Carbon Chain Length	Contaminants: Abbreviation	Freundlich Parameters (Filtrasorb 400) K (mg/g) (L/mg)	1/n	Co [mg/l]	Freundlich Adsorptivity [g contam/100 g GAC]	Freundlich GAC Consumption [lb/mil. gal treated]	Predicted GAC Consumption [lb/mil. gal treated]
4	PFBA	0	0	0			
4	PFBS	113	0.98	0	0.0000		0.0
5	PFPeA	0	0	0			
5	PFPeS	0	0	0			
6	PFHxA	39400	1.45	0	0.0000		0.0
6	PFHxS	21400	1.52	0	0.0000		0.0
7	PFHpA	0	0	0			
7	PFHpS	0	0	0			
8	PFOA	14.317	0.2504	1.13333E-05	0.1466	0.0	0.0
8	PFOS	25.9	0.9	0.000368654	0.0000	7.3	10.5
8 + 1	8 + 1 Acid	0	0	0			
8 + 2	8 + 2 Acid	0	0	0			
9	PFNA	0	0	0			
9	PFNS	0	0	0			
10	PFDA	0	0	0			
10	PFDS	0	0	0			
11	PFUDA	0	0	0			
12	PFDoA	0	0	0			
13	PFTrDA	0	0	0			
14	PFTeDA	0	0	0			
			Total:	0.000380	mg/L =	379.9871795 ng/L	
							10.46

Conclusion: PFOS governs, (the consumption figures are not cumulative). Assume GAC per pound cost of
$ 1.85 including handling and reactivation, yields a treatment cost of
$ 0.0194 per thousand gallons treated.

Flow rate = 650 GPM results in GAC consumption of 9.793599 pounds per day

Filter run length based on 40,000 pound filtration system GAC capacity = 4084.30 days.
11.190 Years

Hourly GAC cost for 650 gpm continuous flow = $ 0.75
Annual GAC cost for 650 gpm continuous flow = $ 6,613.13

The calculations are based on use of Coal based Filtrasorb 400 AW (Acid Washed)

Former Fire House GAC Consumption
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

GAC consumption for the treatment system is predicted based on projections of well flow rates, influent concentrations and dilution factors.

The rate of carbon exhaustion through contaminant loading to a GAC filter can be predicted utilizing the Freundlich adsorption isotherm and field experience. Large cone-bottom vessels such as a Calgon Model 10 can achieve up to 70% of the Freundlich predicted capacity when placed in continuous use and not exposed to frequent venting.
The following analysis assumes relatively low contaminant levels such that competition between compounds for reaction sites can be ignored

The Freundlich isotherm is expressed as: (Co - Cf) / M = K (Cf) **1/n
where : Co = contaminant concentration of the influent
Cf = contaminant concentration of the effluent
M = Total mass of the carbon
K and 1/n = empirical constants unique to the contaminants and carbon

The adsorptivity is estimated at saturation by setting Cf = Co yielding the following form:
Freundlich Adsorptivity = K * Co** 1/n , where Co = Cf [mg/l]

The rate of carbon consumption is estimated as follows:
pounds carbon / million gal. treated = Co [ug/l] / 1000 [ug/mg] / Freundlich Adsorptivity [mg/gram carbon] / 453.59 [gm/lb] * 3,785,000 [liter/million gallons]

Carbon Chain Length	Contaminants: Abbreviation	Freundlich Parameters (Filtrasorb 400) K (mg/g) (L/mg)	1/n	Co [mg/l]	Freundlich Adsorptivity [g contam/100 g GAC]	Freundlich GAC Consumption [lb/mil. gal treated]	Predicted GAC Consumption [lb/mil. gal treated]
4	PFBA	0	0	0			
4	PFBS	113	0.98	0	0.0000		0.0
5	PFPeA	0	0	0			
5	PFPeS	0	0	0			
6	PFHxA	39400	1.45	0	0.0000		0.0
6	PFHxS	21400	1.52	0	0.0000		0.0
7	PFHpA	0	0	0			
7	PFHpS	0	0	0			
8	PFOA	14.317	0.2504	4.44444E-05	0.2065	0.0	0.0
8	PFOS	25.9	0.9	0.000322222	0.0000	7.2	10.3
8 + 1	8 + 1 Acid	0	0	0			
8 + 2	8 + 2 Acid	0	0	0			
9	PFNA	0	0	0			
9	PFNS	0	0	0			
10	PFDA	0	0	0			
10	PFDS	0	0	0			
11	PFUDA	0	0	0			
12	PFDoA	0	0	0			
13	PFTrDA	0	0	0			
14	PFTeDA	0	0	0			
			Total:	0.000367	mg/L =	366.6666667 ng/L	
							10.3

Conclusion: PFOS governs, (the consumption figures are not cumulative). Assume GAC per pound cost of
$ 1.85 including handling and reactivation, yields a treatment cost of
$ 0.0191 per thousand gallons treated.

Flow rate = 300 GPM results in GAC consumption of 4.459682 pounds per day

Filter run length based on 40,000 pound filtration system GAC capacity = 8969.25 days.
24.57 years

Hourly GAC cost for 300 gpm continuous flow = $ 0.34
Annual GAC cost for 300 gpm continuous flow = $ 3,011.40

The calculations are based on use of Coal based Filtrasorb 400 AW (Acid Washed)

Calgon Carbon Isotherm Data
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Isotherm data was available for PFOA on F400 GAC. This data was provided by Calgon Carbon Corp.

The rate of carbon exhaustion through contaminant loading to a GAC filter can be predicted utilizing the Freundlich adsorption isotherm and field experience. Large cone-bottom vessels such as a Calgon Model 10 can achieve up to 70% of the Freundlich predicted capacity when placed in continuous use and not exposed to frequent venting.
The following analysis assumes relatively low contaminant levels such that competition between compounds for reaction sites can be ignored

The Freundlich isotherm is expressed as: (Co - Cf) / M = K (Cf) **1/n
where : Co = contaminant concentration of the influent
Cf = contaminant concentration of the effluent
M = Total mass of the carbon
K and 1/n = empirical constants unique to the contaminants and carbon

The adsorptivity is estimated at saturation by setting Cf = Co yielding the following form:
Freundlich Adsorptivity = K * Co** 1/n , where Co = Cf [mg/l]

The rate of carbon consumption is estimated as follows:
pounds carbon / million gal. treated = Co [ug/l] / 1000 [ug/mg] / Freundlich Adsorptivity [mg/gram carbon] / 453.59 [gm/lb] * 3,785,000 [liter/million gallons]

Carbon Chain Length	Contaminants: Abbreviation	Freundlich Parameters (Filtrasorb 400) K	1/n	Co [mg/l]	Freundlich Adsorptivity [g contam/100 g GAC]	Freundlich GAC Consumption [lb/mil. gal treated]	Predicted GAC Consumption [lb/mil. gal treated]	
4	PFBA			0.000175				
4	PFBS			0.000223				
5	PFPeA			0.000127				
5	PFPeS			0.000626				
6	PFHxA			0.000564				
6	PFHxS			0.00371				
7	PFHpA			0.000072				
7	PFHpS			0.000023				
8	PFOA	14.317	0.2504	0.000144	0.2771	0.00043	0.00062	
	PFOA	20.223	0.2817	0.000144	0.2391	0.00050	0.00072	115.92%
8	PFOS			0.00298				
8	PFOSA			0.00033				
8 + 1	8 + 1 Acid			0				
8 + 2	8 + 2 Acid			0				
9	PFNA			0.00004				
9	PFNS			0.0000026				
10	PFDA			0				
10	PFDS			0				
11	PFUDA			0				
12	PFDoA			0				
13	PFTrDA			0				
14	PFTeDA			0				
			Total:	0.0092	mg/L			

Conclusion: Assume that PFOA governs, (the consumption figures are not cumulative). Assume GAC per pound cost of
$ 1.85 including handling and reactivation, yields a treatment cost of
$ 0.000001 per thousand gallons treated.

Flow rate = 1200 GPM results in GAC consumption of 0.001241 pounds per day

Filter run length based on 40,000 pound filtration system GAC capacity = 32,240,790.7 days.

Hourly GAC cost for 1,200 gpm continuous flow = $ 0.0001
Annual GAC cost for 1,200 gpm continuous flow = $ 0.84

The calculations are based on use of Coal based Filtrasorb 400 AW (Acid Washed)

References:

1 Calgon Carbon Corp.

Calgon Carbon Isotherm Data - Sensitivity Analysis
100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Isotherm data was available for PFOA on F400 GAC. This data was provided by Calgon Carbon Corp. The Freundlich Isotherm parameters are interpreted from a performance graph provided by Calgon.

The previous sheet used a best fit line over the entire range of data provided. The following Freundlich parameters are derived from a best fit curve of only the lower concentration portion of the graph.

While the results are similar the predicted adsorptivity varies by a significant percentage from that for the entire data set.

The rate of carbon exhaustion through contaminant loading to a GAC filter can be predicted utilizing the Freundlich adsorption isotherm and field experience. Large cone-bottom vessels such as a Calgon Model 10 can achieve up to 70% of the Freundlich predicted capacity when placed in continuous use and not exposed to frequent venting.

The following analysis assumes relatively low contaminant levels such that competition between compounds for reaction sites can be ignored

The Freundlich isotherm is expressed as: (Co - Cf) / M = K (Cf) **1/n

where : Co = contaminant concentration of the influent
Cf = contaminant concentration of the effluent
M = Total mass of the carbon
K and 1/n = empirical constants unique to the contaminants and carbon

The adsorptivity is estimated at saturation by setting Cf = Co yielding the following form:
Freundlich Adsorptivity = K * Co** 1/n , where Co = Cf [mg/l]

The rate of carbon consumption is estimated as follows:
pounds carbon / million gal. treated = Co [ug/l] / 1000 [ug/mg] / Freundlich Adsorptivity [mg/gram carbon] / 453.59 [gm/lb] * 3,785,000 [liter/million gallons]

Carbon Chain Length	Contaminants: Abbreviation	Freundlich Parameters (Filtrasorb 400) K	1/n	Co [mg/l]	Freundlich Adsorptivity [g contam/100 g GAC]	Freundlich GAC Consumption [lb/mil. gal treated]	Predicted GAC Consumption [lb/mil. gal treated]		SCWA ACT Predicted GAC Consumption	SCWA ACT Influent C0
4	PFBA			0.000175			4184.8		550	0.000023
4	PFBS			0.000223						
5	PFPeA			0.000127			459.4		170	0.000047
5	PFPeS			0.000626						
6	PFHxA			0.000564			1025.5		100	0.000055
6	PFHxS			0.00371						
7	PFHpA			0.000072						
7	PFHpS			0.000023						
8	PFOA	14.317	0.2504	0.000144	0.2771	0.00043	0.00062			
	PFOA	20.223	0.2817	0.000144	0.2391	0.00050	0.00072	115.92%		
8	PFOS			0.00298						
8	PFOSA			0.00033						
8 + 1	8 + 1 Acid			0						
8 + 2	8 + 2 Acid			0						
9	PFNA			0.00004						
9	PFNS			0.0000026						
10	PFDA			0						
10	PFDS			0						
11	PFUDA			0						
12	PFDoA			0						
13	PFTrDA			0						
14	PFTeDA			0						
			Total:	0.0092	mg/L					

Conclusion: PFBA governs, (the consumption figures are not cumulative). Assume GAC per pound cost of
$ 1.85 including handling and reactivation, yields a treatment cost of
$ 7.74 per thousand gallons treated.

Flow rate = 1200 GPM results in GAC consumption of 7231.3 pounds per day

Filter run length based on 40,000 pound filtration system GAC capacity = 5.5 days.

Hourly GAC cost for 1,200 gpm continuous flow = $ 557.41
Annual GAC cost for 1,200 gpm continuous flow = $ 4,882,938.26

The calculations are based on use of Coal based Filtrasorb 400 AW (Acid Washed)

References:

1 Calgon Carbon Corp.

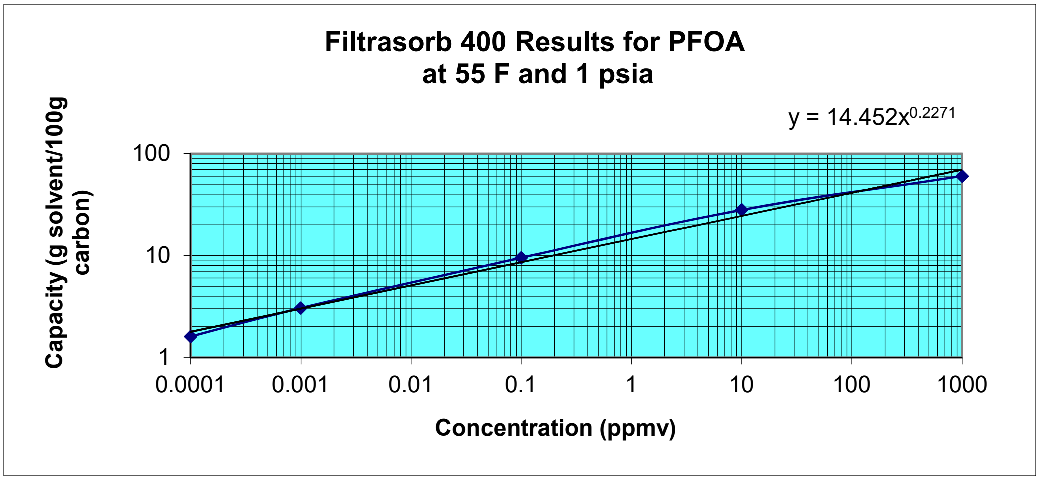
100% Design Submittal

Brookhaven National Laboratory **June-21**

PFAS Source Area Removal - Treatment Options

Current & Former Fire House Remediation Wells

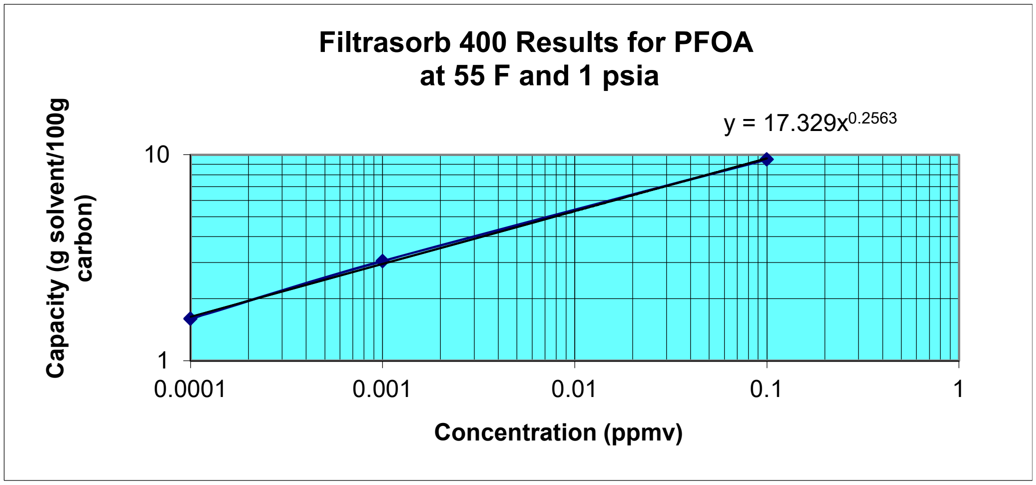
Capacity (g solvent/100g carbon)	Concentration (ppmv)
1.6	0.0001
3.05	0.001
9.5	0.1
28	10
60	1000



100% Design Submittal

Brookhaven National Laboratory **June-21**
PFAS Source Area Removal - Treatment Options
Current & Former Fire House Remediation Wells

Capacity (g solvent/100g carbon)	Concentration (ppmv)
1.6	0.0001
3.05	0.001
9.5	0.1



PLC IO List
100% Design Submittal

Brookhaven National Laboratory
PFAS Source Area Removal
Current & Former Fire House Remediation Wells

June-21

Partial I/O list - Current Fire House

Digital Inputs:

Designation	Description	
DI - CFWA-1	CF-RW-A	High Water Signal
DI - CFWA-2	CF-RW-A	Low Pressure Signal
DI - CFWA-3	CF-RW-A	High Pressure Signal
DI - CFWA-4	CF-RW-A	Starter Energized Signal
DI - CFWA-5	CF-RW-A	Vault Intrusion Signal
DI - CFWA-6	CF-RW-A	HOA Switch on Auto
DI - CFWB-1	CF-RW-B	High Water Signal
DI - CFWB-2	CF-RW-B	Low Pressure Signal
DI - CFWB-3	CF-RW-B	High Pressure Signal
DI - CFWB-4	CF-RW-B	Starter Energized Signal
DI - CFWB-5	CF-RW-B	Vault Intrusion Signal
DI - CFWB-6	CF-RW-B	HOA Switch on Auto
DI - CFWC-1	CF-RW-C	High Water Signal
DI - CFWC-2	CF-RW-C	Low Pressure Signal
DI - CFWC-3	CF-RW-C	High Pressure Signal
DI - CFWC-4	CF-RW-C	Starter Energized Signal
DI - CFWC-5	CF-RW-C	Vault Intrusion Signal
DI - CFWC-6	CF-RW-C	HOA Switch on Auto
DI - CFWD-1	CF-RW-D	High Water Signal
DI - CFWD-2	CF-RW-D	Low Pressure Signal
DI - CFWD-3	CF-RW-D	High Pressure Signal
DI - CFWD-4	CF-RW-D	Starter Energized Signal
DI - CFWD-5	CF-RW-D	Vault Intrusion Signal
DI - CFWD-6	CF-RW-D	HOA Switch on Auto
DI - CFWE-1	CF-RW-E	High Water Signal
DI - CFWE-2	CF-RW-E	Low Pressure Signal
DI - CFWE-3	CF-RW-E	High Pressure Signal
DI - CFWE-4	CF-RW-E	Starter Energized Signal
DI - CFWE-5	CF-RW-E	Vault Intrusion Signal
DI - CFWE-6	CF-RW-E	HOA Switch on Auto

Digital Outputs:

Device Location	Designation	Description	
Remote	DO - W1-1	CF-RW-A	Run signal to starter
Remote	DO - W1-2	CF-RW-A	Run status light
Remote	DO - W1-3	CF-RW-A	Energize Run Time Meter
Remote	DO - W2-1	CF-RW-B	Run signal to starter
Remote	DO - W2-2	CF-RW-B	Run status light
Remote	DO - W2-3	CF-RW-B	Energize Run Time Meter
Remote	DO - W3-1	CF-RW-C	Run signal to starter
Remote	DO - W3-2	CF-RW-C	Run status light
Remote	DO - W3-3	CF-RW-C	Energize Run Time Meter
Remote	DO - W5-1	CF-RW-D	Run signal to starter
Remote	DO - W5-2	CF-RW-D	Run status light
Remote	DO - W5-3	CF-RW-D	Energize Run Time Meter
Remote	DO - W6-1	CF-RW-E	Run signal to starter
Remote	DO - W6-2	CF-RW-E	Run status light
Remote	DO - W6-3	CF-RW-E	Energize Run Time Meter

PLC IO List
100% Design Submittal

Brookhaven National Laboratory
PFAS Source Area Removal
Current & Former Fire House Remediation Wells

June-21

Partial I/O list - Former Fire House

Digital Inputs:

Designation	Description	
DI - FFWA-1	FF-RW-A	High Water Signal
DI - FFWA-2	FF-RW-A	Low Pressure Signal
DI - FFWA-3	FF-RW-A	High Pressure Signal
DI - FFWA-4	FF-RW-A	Starter Energized Signal
DI - FFWA-5	FF-RW-A	Vault Intrusion Signal
DI - FFWA-6	FF-RW-A	HOA Switch on Auto
DI - FFWB-1	FF-RW-B	High Water Signal
DI - FFWB-2	FF-RW-B	Low Pressure Signal
DI - FFWB-3	FF-RW-B	High Pressure Signal
DI - FFWB-4	FF-RW-B	Starter Energized Signal
DI - FFWB-5	FF-RW-B	Vault Intrusion Signal
DI - FFWB-6	FF-RW-B	HOA Switch on Auto
DI - FFWC-1	FF-RW-C1	High Water Signal
DI - FFWC-2	FF-RW-C2	Low Pressure Signal
DI - FFWC-3	FF-RW-C3	High Pressure Signal
DI - FFWC-4	FF-RW-C4	Starter Energized Signal
DI - FFWC-5	FF-RW-C5	Vault Intrusion Signal
DI - FFWC-6	FF-RW-C6	HOA Switch on Auto

Digital Outputs:

Device Location	Designation	Description	
Remote	DO - W1-1	FF-RW-A	Run signal to starter
Remote	DO - W1-2	FF-RW-A	Run status light
Remote	DO - W1-3	FF-RW-A	Energize Run Time Meter
Remote	DO - W2-1	FF-RW-B	Run signal to starter
Remote	DO - W2-2	FF-RW-B	Run status light
Remote	DO - W2-3	FF-RW-B	Energize Run Time Meter
Remote	DO - W3-1	FF-RW-C1	Run signal to starter
Remote	DO - W3-2	FF-RW-C2	Run status light
Remote	DO - W3-3	FF-RW-C3	Energize Run Time Meter
Local	DO - WF-1	Any Well High Pressure status light	
Local	DO - WF-2	Any Well Low Pressure status light	

Appendix B
BNL CFH PFAS Capture Evaluation Memo, Arcadis

Memo

SUBJECT BNL CFH PFAS Capture Evaluation	**TO** Bob Holzmacher, J.R. Holzmacher P.E., LLC
DATE April 15, 2021	**OUR REF**
DEPARTMENT ENVIRONMENT	**PROJECT NUMBER** 30066617.00001
COPIES TO Vincent Racaniello, BNL File	**NAME** Robert Porsche rporsche@arcadis-us.com

This memo documents the work performed in support of the design of a groundwater pump and treat system for the per- and polyfluoroalkyl substances (PFAS) plume associated with the Current Fire House (CFH). Specifically, this memo documents the capture analysis conducted to evaluate the locations and extraction rates of proposed remedial wells. This modeling effort was completed following an update of the BNL Regional Groundwater Flow Model and the development of a new CFH PFAS sub-model. The work was conducted under contract to JR Holzmacher, the engineering firm designing the PFAS remediation system for the CFH.

INTRODUCTION

This modeling effort was performed to evaluate hydraulic capture of PFAS-impacted groundwater emanating from the Current Fire House and focused on designing a remedial well network with the goal of capturing PFAS-impacted groundwater at concentrations of 100 nanograms/Liter (ng/L) or higher. Initial remedial well locations and their associated screen zones were collaboratively developed by JR Holzmacher and BNL managers, based on the distribution of PFAS-impacted groundwater noted during the recently completed characterization efforts. Figures depicting the distribution of PFAS in the vicinity of the CFH included with this memo as Attachments 1- 3. Initially, the preliminary design consisted of a network of nine remedial wells, arrayed in three lines. Moving south from the source area, the first line included Current Fire House Remedial Wells CF-RW-A and CF-RW-B, the second line included CF-RW-C, CF-RW-D and CF-RW-E, and the third line include CF-RW-F, CF-RW-G and CF-RW-H. At the CF-RW-C and CF-RW-E locations, two wells were proposed, screened to capture both shallow and deep PFAS-impacted groundwater.

This work was conducted in support of the Groundwater Protection Group of BNL's Environmental Protection Division's remedial design efforts, with Arcadis working under contract to JR Holzmacher, the remedial system design engineers. The modeling software Groundwater Vistas (Version 7.24 Build 70), a graphical user interface which serves as a pre- and post-processor for MODFLOW (McDonald, 1988) and MODPATH (Pollack, 1994), was used to develop the CFH PFAS sub-model, update hydraulic parameters and boundary conditions, and delineate the CFH PFAS plume. MODFLOW is the U.S. Geological Survey's modular finite-difference flow model and is used to simulate groundwater flow. MODPATH is a particle tracking post-processing package developed to compute three-dimensional flow paths using output from steady-state or transient groundwater flow simulations completed with MODFLOW.

KEY ASSUMPTIONS AND MODEL MODIFICATIONS

The CFH PFAS flow and particle tracking simulations described herein were conducted using a purpose-built sub-model, derived from the recently updated regional groundwater flow model.

The following key assumptions were made for this modeling effort:

- Properties and boundary conditions in the sub-model were inherited from the recently calibrated and updated Regional Groundwater Flow Model (Arcadis, 2020). **Figure 1** shows the layers of the sub-model and the associated horizonal hydraulic conductivities assigned to the sub-model layers.
- Aerial extent of sub-model:
  - Approximately 7,800 ft in the east-west direction.
  - Approximately 12,000 ft in the north-south direction.
- Following extraction of the sub-model, layers 1 and 2 were divided into 10 layers, with each layer having a thickness of 10 ft in the area downgradient of the CFH.
- There were no changes made to the sub-model which would alter flow directions or rates of flow predicted by the regional flow model. No changes were made to aerial recharge rates or boundary flow conditions.
- Groundwater flow and transport were simulated under steady state conditions.

SUB-MODEL DEVELOPMENT

The sub-model was developed using a process called telescopic mesh refinement (TMR), which enables the development of a sub-model from a larger model while preserving the model parameters, structure, and boundary conditions.

TMR is a well-accepted method for developing sub-models or simply refining more regional scale models in an area of interest. Arcadis developed a simple FORTRAN utility which enables the user to easily create a new model that inherits the properties and boundary conditions from the parent or regional model.

TMR was used to extract a portion of the regional groundwater flow model and modify model grid cell sizes and the discretization of what was formerly regional model layers 1 and 2.

The sub-model includes all eight layers from the regional groundwater flow model, reconfigured as follows:

- Regional model layers 1 and 2 correspond to sub-model layers 1 through 5 and 6 through 10, respectively; with each layer having a thickness in the sub-model of 10 ft.
- Regional model layers 3 through 8 correspond to sub-model layers 11 – 16; the thickness of these layers in the sub-model are unchanged from the regional model.

Sub-Model Discretization

Following development of the sub-model, model layers 1 and 2 were modified by splitting each layer into five layers; **see Figure 1**. This was done to enhance the vertical discretization for the purposes of evaluating the vertical movement of the CFH PFAS plume and enabling optimization of the proposed remedial well screens. Following this revision, layers 1 through 10 were each 10-ft thick.

In addition, the model grid was modified to reduce model cell sizes from 100 ft by 100 ft in the regional groundwater flow model to 20 ft by 20 ft in the sub-model over the area of interest.

Model grid and boundary conditions are shown on **Figure 2**.

GROUNDWATER FLOW FIELD

The sub-model's groundwater flow field was derived from the recently updated BNL Regional Groundwater Flow Model. The extracted sub-model is bounded by constant head cells (**Figure 2**). The potentiometric surface of the water table within the sub-model under non-pumping conditions (i.e., no CFH PFAS remedial wells pumping) is shown on the left-hand panel of **Figure 3**. The right-hand panel of Figure 3 shows the potentiometric surface under the influence of the CFH PFAS remedial system, which will be discussed in greater detail below.

The left-hand panel indicates that groundwater in the vicinity of the CFH is flowing to the south-southwest, under the local influences of pumping at public supply well BNL-7 and recharge from the Operable Unit III (OU-III) recharge basins, with water table elevations ranging from about 45 ft above mean sea level (MSL) near the CFH, to about 32 ft MSL at the southern extent of the sub-model. These water level elevations are identical to the water table elevations predicted by the regional groundwater flow model over the area of the sub-model. Hydraulic capture of the CFH PFAS plume was simulated under steady state groundwater flow conditions.

The two panel display of the water table under pre-remediation and remediation conditions demonstrates the impact of the proposed CFH-PFAS remedial system on local groundwater flow, and how the south-southwest trajectory of groundwater flow in this area results from the combined influence of recharge at the OU-III basin and pumping at BNL-7.

DISCUSSION OF MODEL SIMULATION AND RESULTS

The evaluation and optimization of hydraulic capture achieved by the proposed remedial well network was completed through an iterative process of testing the impact of anticipated minimum and maximum pumping rates assigned to the proposed 9 remedial wells, then varying the locations and assigned pumping rates for the wells to achieve capture of the 100 ng/L CFH PFAS plume. During this iterative process, it was recognized that the initial placement of the southernmost line of remedial wells (CF-RW-F, CF-RW-G, and CF-RW-H) were too far east to effectively capture portions of the plume. Shifting this line of wells to the west approximately 300 feet improved capture. The discussion that follows refers to the well network after the adjustment of the southern line of extraction wells.

Forward Particle Tracking

The potential movement of the CFH PFAS plume was evaluated by conducting a forward particle tracking simulation under pre-remediation conditions (i.e., the proposed CFH PFAS containment system was not active). **Figure 4** shows the configuration of the pre-remediation water table, along with the predicted pathlines for particles released in model layer 1, in a west-east trending line just south of the HX and HZ recharge basins.

The simulation tracked the model-predicted movement of the particles. The colors of the particle pathlines indicate the model layers through which the particles are travelling during the simulation. For the purposes of this evaluation, pathlines were truncated after 15 years. The arrowheads along each pathline mark 5 years of travel time (calculated with an aquifer porosity of 15%).

The model-predicted pathline distribution demonstrates that the local groundwater flow field is affected by both the recharge occurring at the OU-III basins, and the pumping of public supply well BNL-7, which results in a southwesterly flow direction for shallow groundwater in this area.

HYDRAULIC CAPTURE ANALYSIS

The following sections describe the proposed remedial well layout, the development of the proposed remedial well locations, pumping rates and screen zones, and the results of the hydraulic capture analysis.

The primary goal of this groundwater modeling exercise was to use the model to develop a proposed remedial well network which would mitigate the continued downgradient movement of the CFH PFAS plume at concentrations above 100 ng/L, with a secondary goal of not affecting/capturing a co-located 1,4-dioxane plume. The capture analysis was an iterative process during which more than 10 capture assessment scenarios were simulated under various combinations of well locations, screen zones and pumping rates. While this modeling effort did not explicitly evaluate the impact of the proposed remedial well network on the 1,4-dioxane plume, the proposed well layout considered the presence of the 1,4-dioxane plume and evaluated the vertical hydraulic capture induced by the proposed network. Proposed pumping rates and screen zones were adjusted to both achieve containment of the PFAS plume and minimize induced capture beneath the PFAS plume. When implemented in the field the proposed system will offer operational flexibility to minimize the impact of this system on the 1,4-dioxane plume. The results presented here describe the final capture simulation, which achieved the goals of the design effort by preventing the continued movement of dissolved PFAS at concentrations above 100 ng/L.

Simulated Pumping Rates

As originally proposed, the CFH PFAS remedial well network consisted of ten remedial wells arrayed in three lines (northern, middle and southern) as follows:

- The northern line of extraction wells included CF-RW-A and CR-RW-B.
- The middle line of extraction wells included CF-RW-C1 (shallow well), CF-RW-C2 (deep well), CF-RW-D, CR-RW-E1 (shallow well), and CF-RW-E2 (deep well).
- The southern line of extraction wells included CF-RW-F, CF-RW-G, and CF-RW-G.

As the capture assessment proceeded, it became evident that the shallow remedial wells proposed at CF-RW-C1 and CF-RW-E1 were not necessary to establish containment of the 100 ng/L PFAS plume. As a result of this determination, CF-RW-C1 and CR-RW-E1 were eliminated from the proposed remedial well network.

Various combinations of well locations, well screen intervals and pumping rates were evaluated during the development of the proposed remedial well network. The evaluation considered system-wide flow rates as high as 800 gpm and as low as 200 gpm and included well networks of as many as 11 wells and as few as 8 wells. The pumping rates and screen zones associated with the final capture simulation are summarized on **Table 1**. Except for remedial well CF-RW-F, all remedial wells were simulated with 20-ft long screens; CF-RW-F was simulated with a 30-ft long screen. Simulated pumping rates across the well network ranged from 30 - 60 gallons per minute (gpm), with the simulated system having a total pumping rate of 360 gpm.

Treated discharge from the CHF PFAS remedial well network will be returned to the aquifer through the OU III basin. During the iterative evaluation, the simulated pumping and recharge rates of BNL-7 and the OU III recharge basins were constrained based on input from BNL facilities staff; the pumping rate of BNL-7 was held fixed at about 500 gpm while the base recharge rate at OU III was 448 gpm.

The treated discharge from the CFH remedial system will be discharged to the OU III basin network, which currently receives water from the Middle Road, South Boundary and Western South Boundary remedial systems

(MR/SR/WSB). However, discharge from the MR/SR/WSB systems enters the OU III basin network via a wet well, which can divert approximately 300 gpm from the OU III basins to the RA V basins. The CFH is anticipated to treat about 360 gpm, all of which will be returned to the aquifer through the OU III basins. However, to mitigate the impact of this additional recharge on the local groundwater flow field, the wet well will be used to divert 300 gpm from the MR/SR/WSB systems to the RA V basin network. For the purposes of this modeling evaluation, operation of the CFH is expected to result in the addition of 60 gpm to the OU III basin network, and 300 gpm to the RA V basin network.

To evaluate the CFH PFAS system, the simulated recharge rate at the OU-III basin was varied based on the simulated PFAS remedial well network's production; under the proposed remedy, 360 gpm will be returned to the aquifer through the OU III basin network.

Simulated Treatment System Discharge

Based on discussions with BNL managers, it is anticipated that up to 300 gpm from the MR/SB/WSB remedial systems will be diverted from the OU III basin network to the RA V basin network. The CFH remedial system's treated water discharge will be returned to the aquifer through the OU III basin network.

With each capture scenario evaluated, the distribution of simulated treated water discharge was adjusted such that 300 gpm was assumed to be diverted from the OU III basin and returned to the aquifer via the RA-V basin, and the remainder of the treated water discharge was simulated as recharge at the OU-III basin. For the final capture simulation, 360 gpm of the simulated treatment system discharge was recharged to the aquifer via the OU-III basin, and 300 gpm was diverted from the OU III basin to the RA V basin.

Proposed Remedial Well Layout

The proposed layout of the remedial well network is shown in the right-hand panel of **Figure 3**; the right-hand panel also shows the impact of the remedial well network on local groundwater flow.

Under pre-remediation conditions (shown on the left-hand panel of Figure 3) the water table contours exhibit a southwesterly trend in groundwater flow. This tendency for southwesterly flow is amplified by the operation of the CFH PFAS remedial well network, and the associated additional recharge at the OU-III basin (shown on the right-hand panel of Figure 3).

Endpoint Analysis

The extent (vertically and horizontally) of the capture zone resulting from the operation of the proposed CFH PFAS remedial well network was determined through an endpoint analysis. For this analysis, a "cloud" of particles is released throughout the model area, such that particles are started within each model cell over an area that encompasses and extends beyond the limits of the portion of the aquifer targeted for capture (i.e., the 100 ng/L PFAS plume).

Under the simulated groundwater flow field resulting from the operation of the remedial well network and the local recharge of groundwater to the OU-III basin, particles are tracked from their starting point to their endpoint. When a particle's starting location corresponds to an ending location at one of the CFH-PFAS remedial wells, the starting location is marked with a solid color fill. The resulting figure uses fills of different colors to show the capture zones associated with each of the proposed remedial wells. **Figures 5 - 15** show the model predicted capture zones associated with the CFH-PFAS remedial well network, in model layers 1 through 11, respectively.

On each figure the capture zones of the remedial wells are identified with a unique color fill. The figures show both the model predicted area of capture and the extent of the 100 ng/L PFAS plume in each model layer.

In aggregate, the area of capture established by the CFH-PFAS remedial well system is predicted to capture the 100 ng/L PFAS plume.

CONCLUSIONS

The results of this modeling effort suggest that hydraulic containment of the majority of the CFH PFAS plume at concentrations of 100 ng/L or higher can be achieved with a network of 8 remedial wells, pumping (in total) 360 gpm, and returning the treated water to the aquifer through the OU-III recharge basin. This configuration results in optimized capture of the CFH PFAS plume; the area of hydraulic capture is focused to encompass the extent of the PFAS plume while limiting the vertical extent of capture such that capture of the 1,4-dioxane plume present beneath the PFAS is minimized.

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Arcadis, 1999 Regional Groundwater Model Update, Brookhaven National Laboratory, Upton, New York. Prepared for Brookhaven National Laboratory, Brookhaven Science Associates. July 30, 1999

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McDonald, Michael G. and Arlen W. Harbaugh. 1988. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model. Techniques of Water-Resources Investigations of the United States Geological Survey, Chapter A1.

Pollack, David W. 1994. User's guide for MODPATH/MODPATH-Plot, Version 3; a particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model. Open-File Report 94-464.

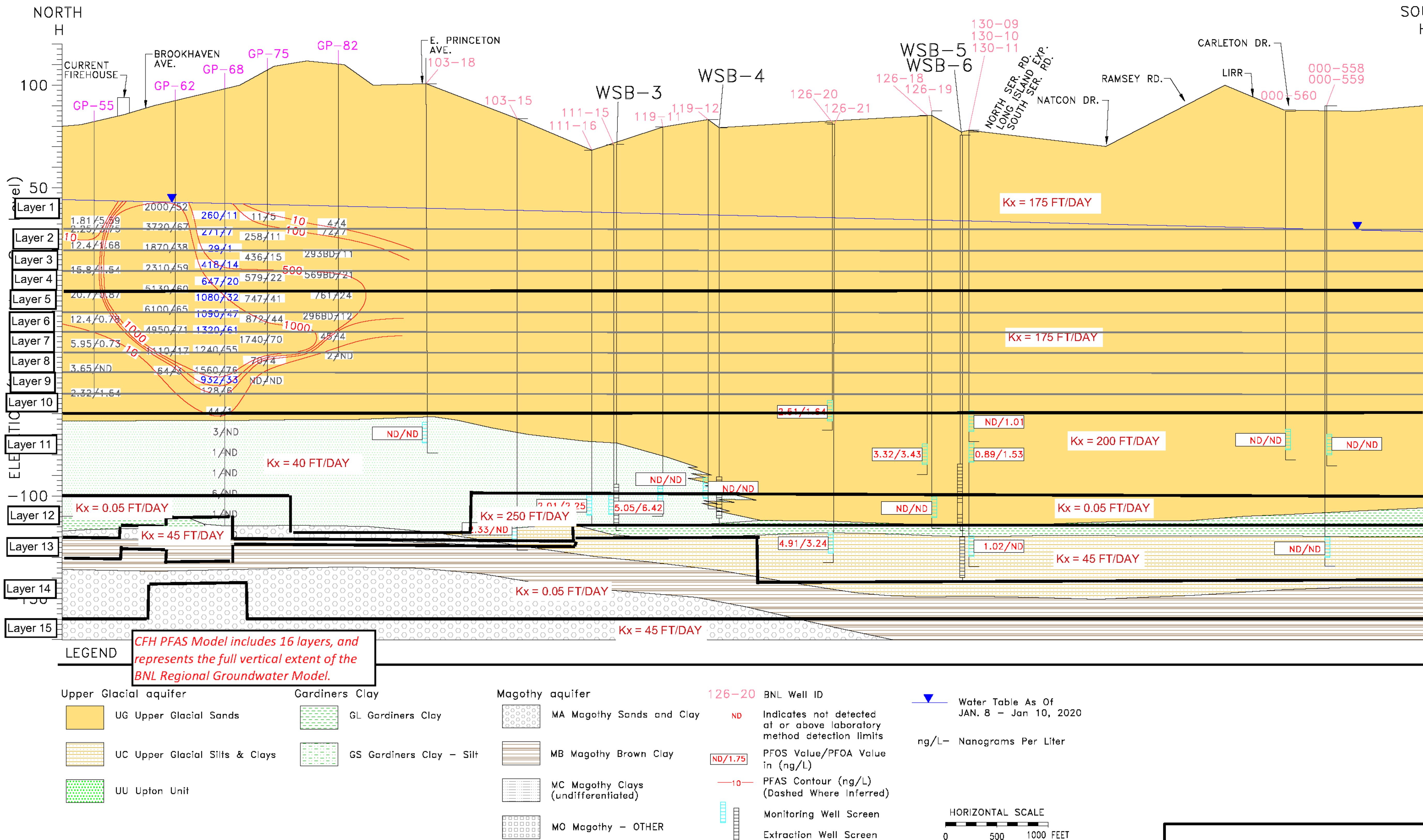
Table 1.
Summary of Simulated Pumping Rate and Well Screen Zone,
Current Fire House PFAS Capture
Brookhaven National Laboratory
Upton, New York.

Well ID	Pumping Rate (gpm)	Elevation Screen Top (ft msl)	Elevation Screen Bottom (ft msl)	Screen Length (ft)	Model Layers Screened
CF-RW-A	30	36	16	20	1, 2, 3
CF-RW-B	30	30	10	20	1, 2, 3
CF-RW-C2	60	-17	-37	20	6, 7, 8
CF-RW-D	30	30	10	20	1, 2, 3
CF-RW-E2	60	-32	-52	20	8, 9, 10
CF-RW-F	50	-20	-50	30	6, 7, 8, 9
CF-RW-G	50	5	-15	20	4, 5, 6
CF-RW-H	50	0	-20	20	4, 5, 6
Total Flow:	**360**				

gpm - gallons per minute.

ft - feet.

ft msl - feet relatvie to mean sea level.



NOTES:

1. GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g. HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

NOTES (continued):

2. PFOS/PFOA RESULTS BASED ON JANUARY 23 - SEPTEMBER 23 2020 SAMPLING EVENTS.
3. CONTOUR INTERVAL IS AS SHOWN.
4. BNL WELL ID COLOR CORRESPONDS TO LONG-TERM MONITORING PROGRAM WELL LOCATION MAP.

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CURRENT FIREHOUSE AREA SUBMODEL CROSS-SECTION

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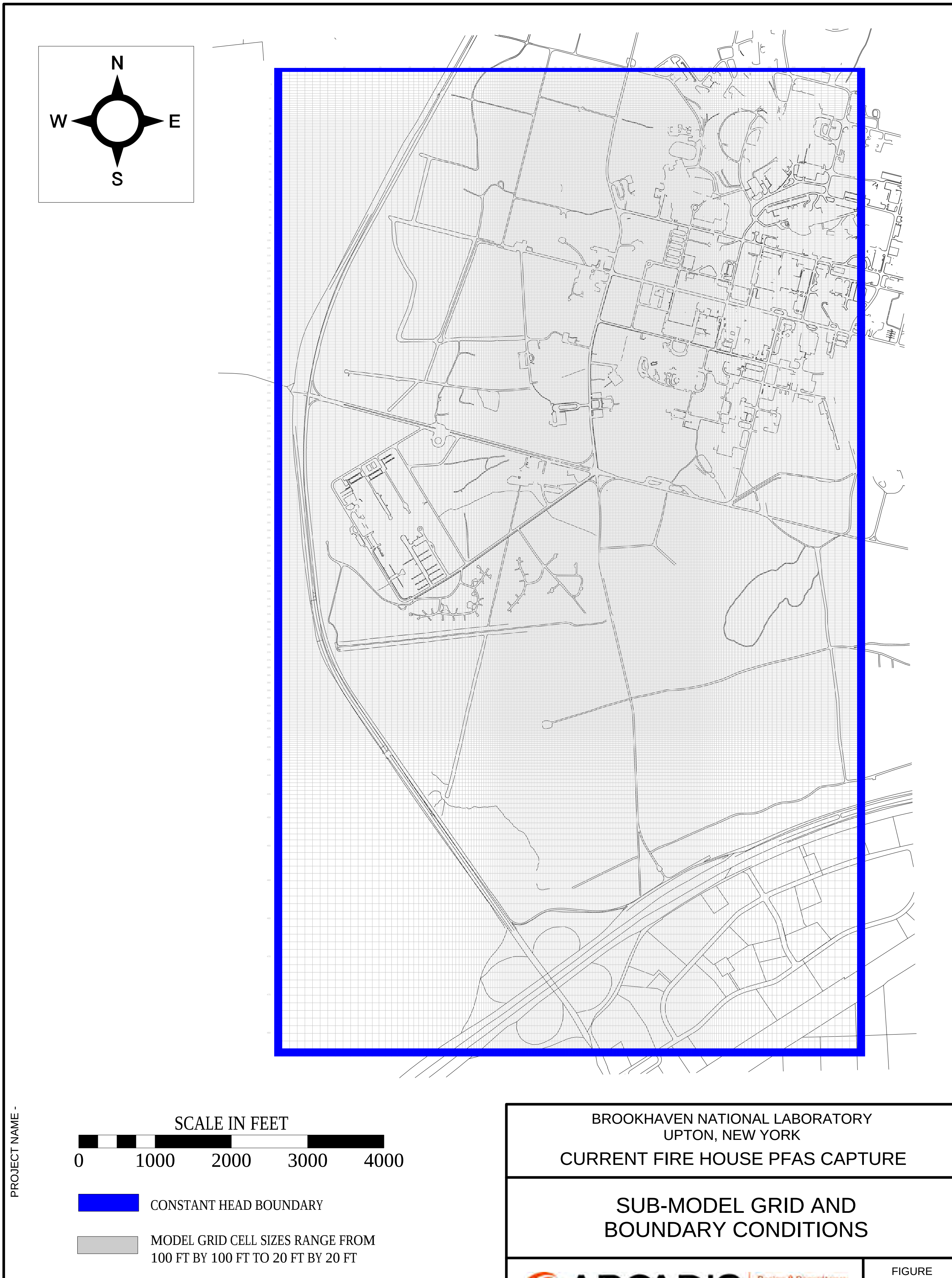
FIGURE 1



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UPTON, NEW YORK
CURRENT FIRE HOUSE PFAS CAPTURE

SUB-MODEL GRID AND BOUNDARY CONDITIONS

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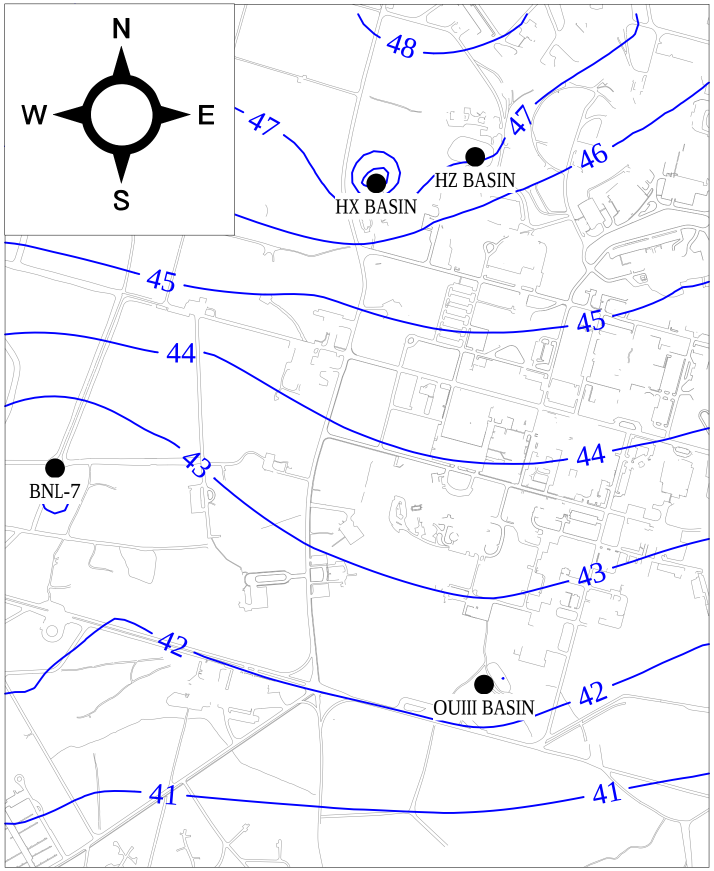
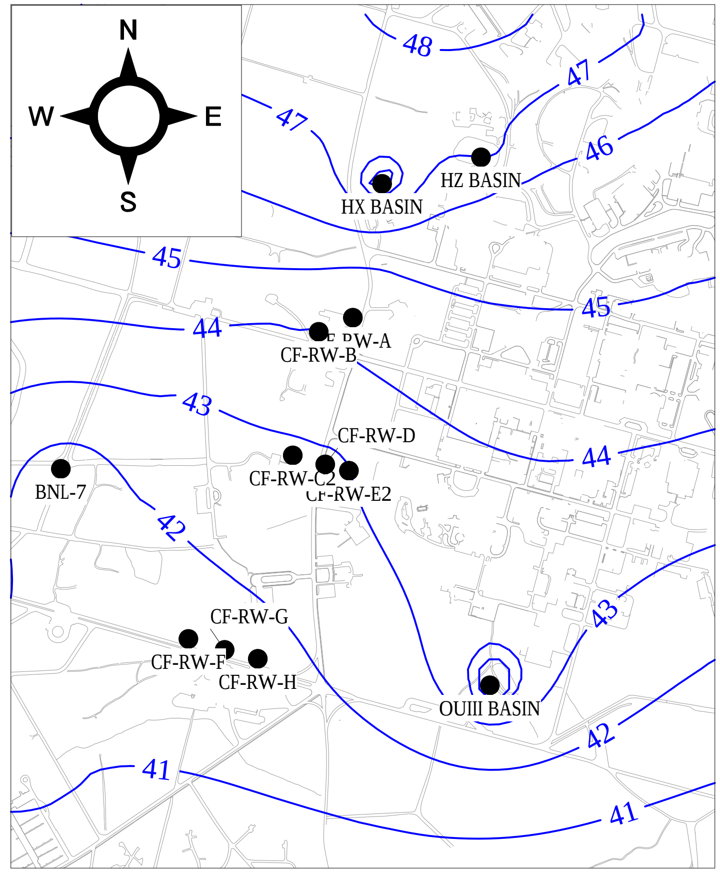
FIGURE 2

PRE-REMEDIATION WATER TABLE



MODEL PREDICTED WATER TABLE



SCALE IN FEET

0 1000 2000 3000 4000

41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

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CURRENT FIRE HOUSE PFAS CAPTURE

PRE-REMEDIATION AND MODEL-PREDICTED WATER TABLE CONFIGURATION

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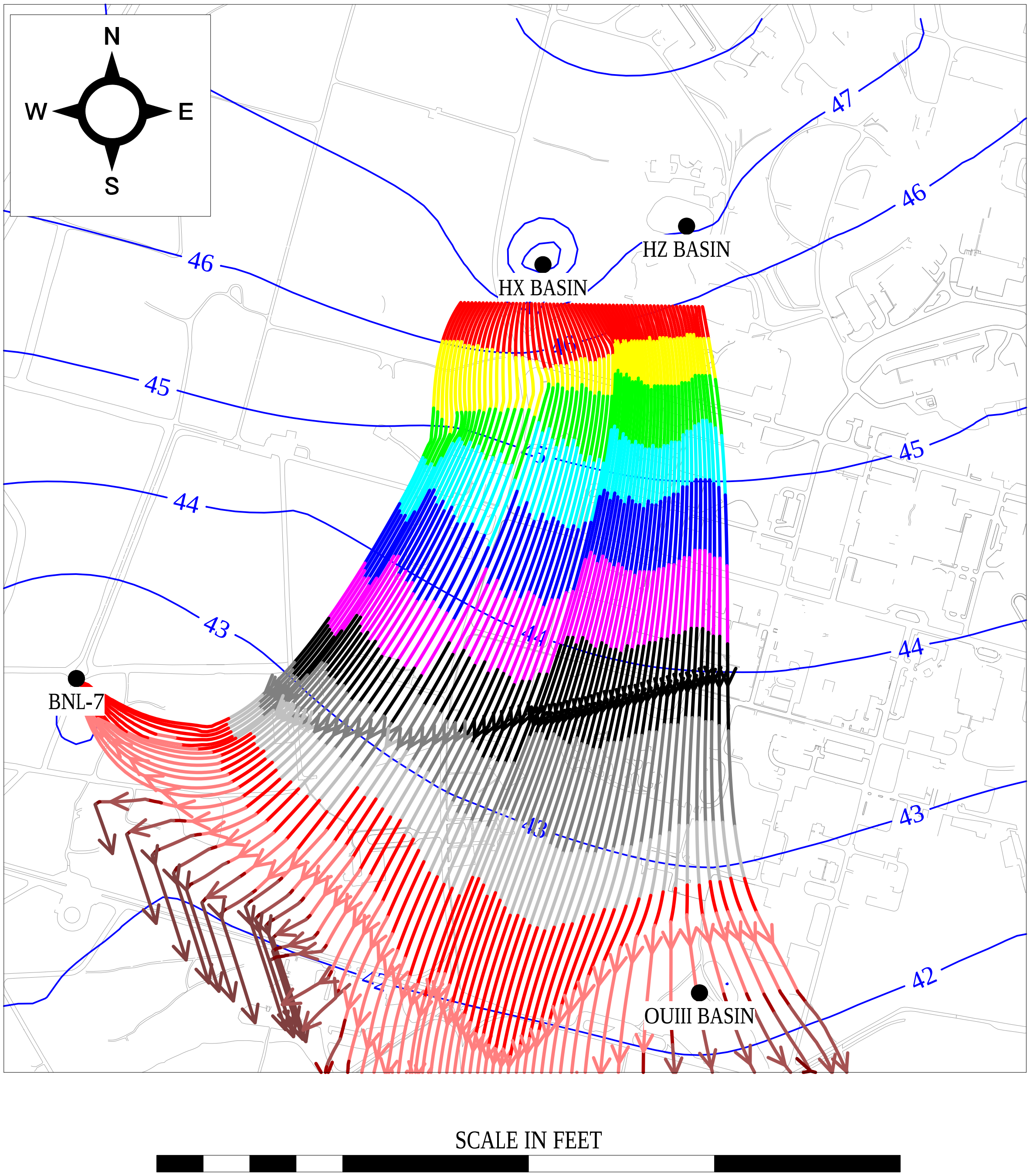
FIGURE
3



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

PARTICLE PATH IN MODEL LAYER 1
PARTICLE PATH IN MODEL LAYER 2
PARTICLE PATH IN MODEL LAYER 3
PARTICLE PATH IN MODEL LAYER 4
PARTICLE PATH IN MODEL LAYER 5
PARTICLE PATH IN MODEL LAYER 6
PARTICLE PATH IN MODEL LAYER 7
PARTICLE PATH IN MODEL LAYER 8
PARTICLE PATH IN MODEL LAYER 9
PARTICLE PATH IN MODEL LAYER 10
PARTICLE PATH IN MODEL LAYER 11
PARTICLE PATH IN MODEL LAYER 12
PARTICLE PATH IN MODEL LAYER 13
ARROWHEAD INDICATES 5 YEARS TRAVEL

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CURRENT FIRE HOUSE PFAS CAPTURE

PRE-REMEDIATION WATER TABLE CONFIGURATION AND PARTICLE FLOW PATHS

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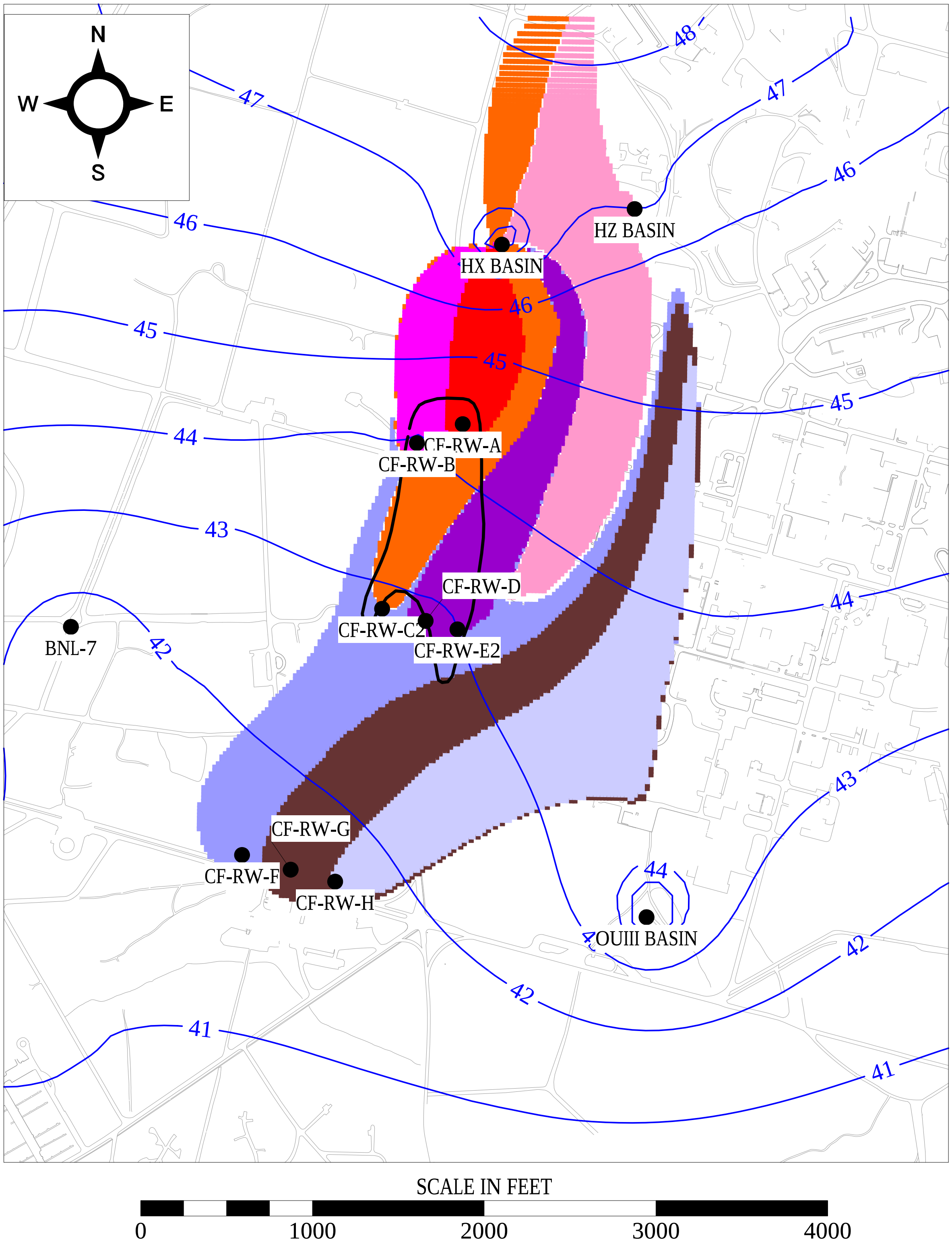
FIGURE 4



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE

CF-RW-B CAPTURE ZONE

CF-RW-C2 CAPTURE ZONE

CF-RW-D CAPTURE ZONE

CF-RW-E2 CAPTURE ZONE

CF-RW-F CAPTURE ZONE

CF-RW-G CAPTURE ZONE

CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 1

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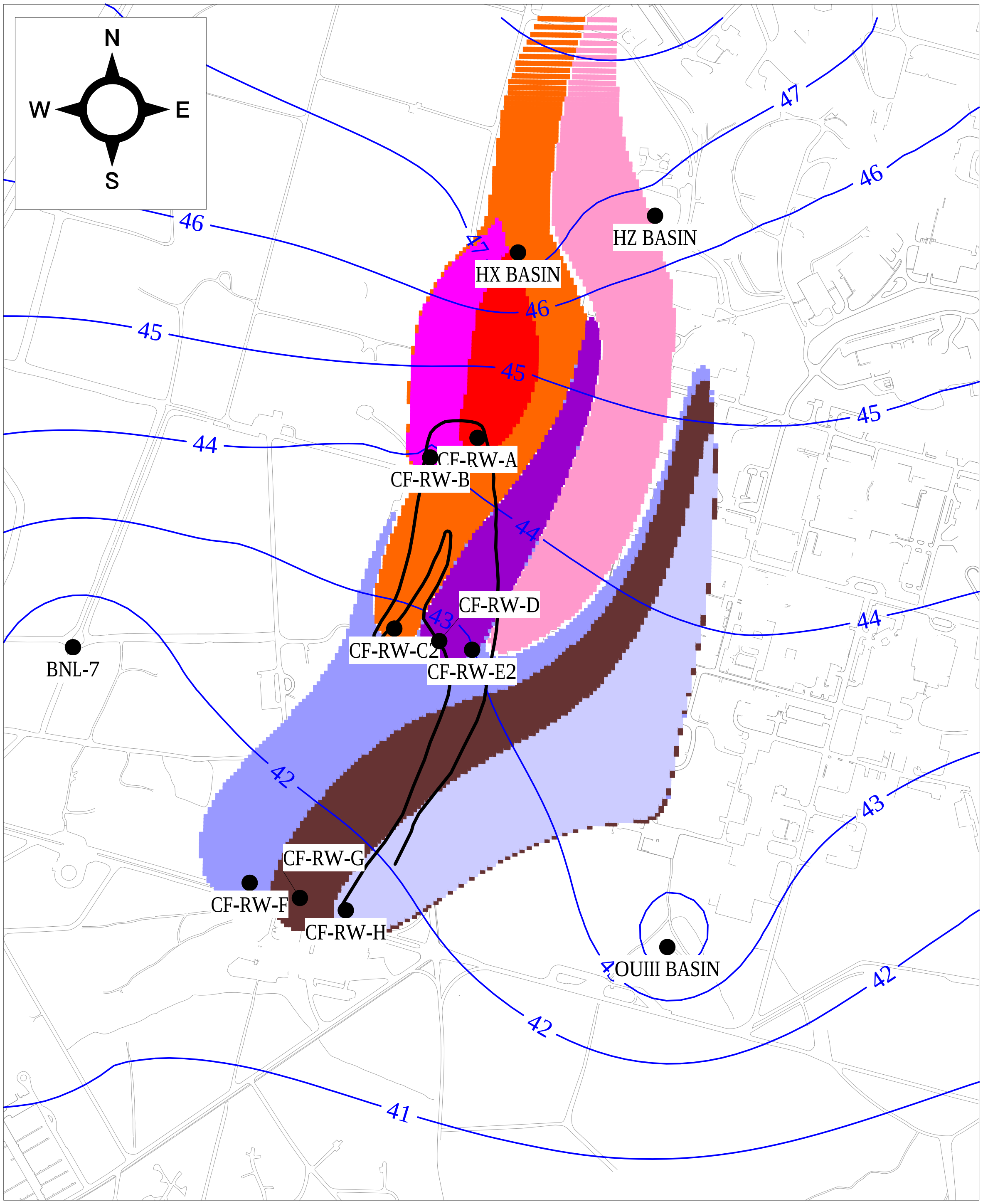
FIGURE
5



SCALE IN FEET

0 1000 2000 3000 4000

41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE

CF-RW-B CAPTURE ZONE

CF-RW-C2 CAPTURE ZONE

CF-RW-D CAPTURE ZONE

CF-RW-E2 CAPTURE ZONE

CF-RW-F CAPTURE ZONE

CF-RW-G CAPTURE ZONE

CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 2

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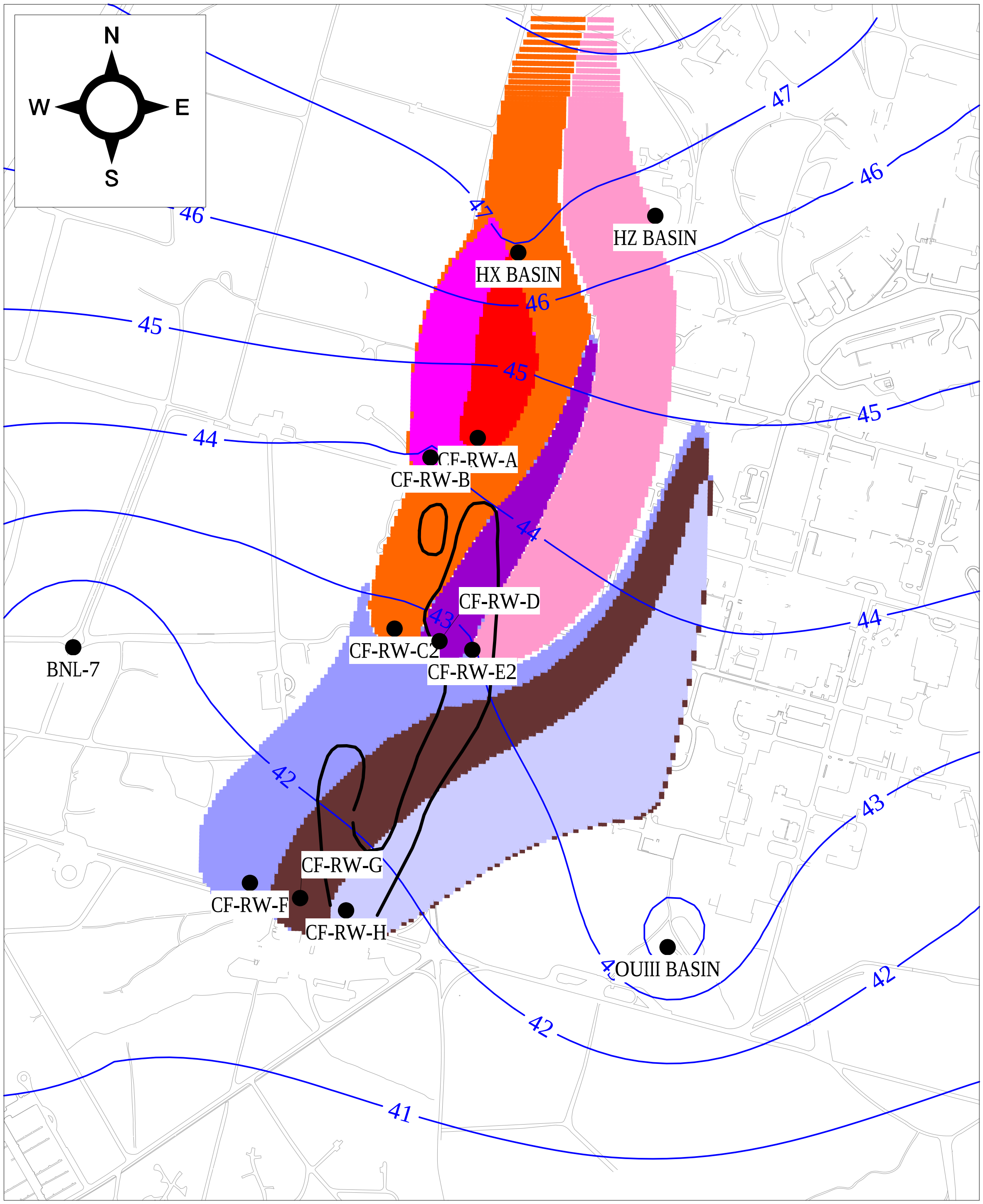
FIGURE
6



SCALE IN FEET

0 1000 2000 3000 4000

41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE
CF-RW-B CAPTURE ZONE
CF-RW-C2 CAPTURE ZONE
CF-RW-D CAPTURE ZONE
CF-RW-E2 CAPTURE ZONE
CF-RW-F CAPTURE ZONE
CF-RW-G CAPTURE ZONE
CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 3

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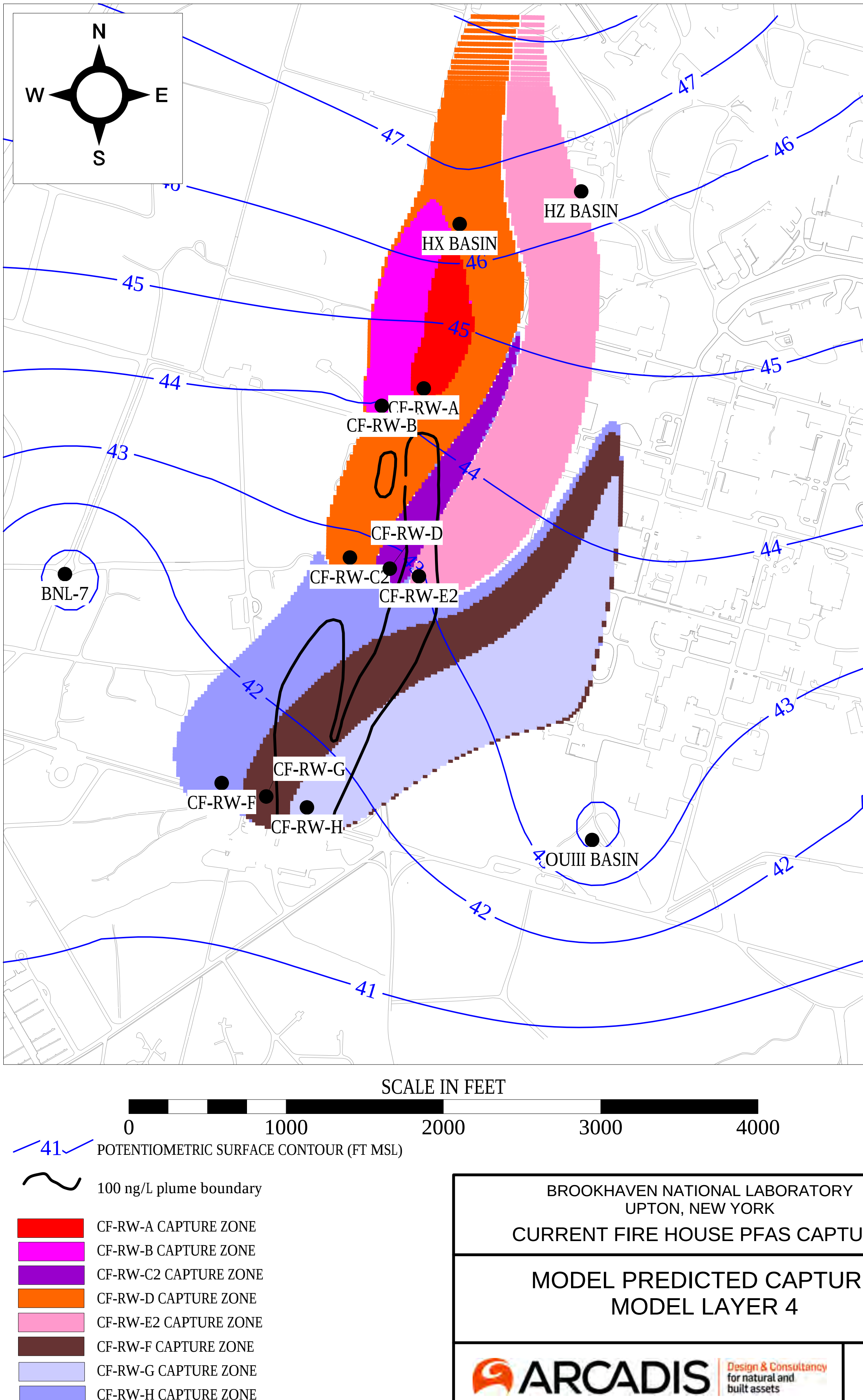
FIGURE
7



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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 4

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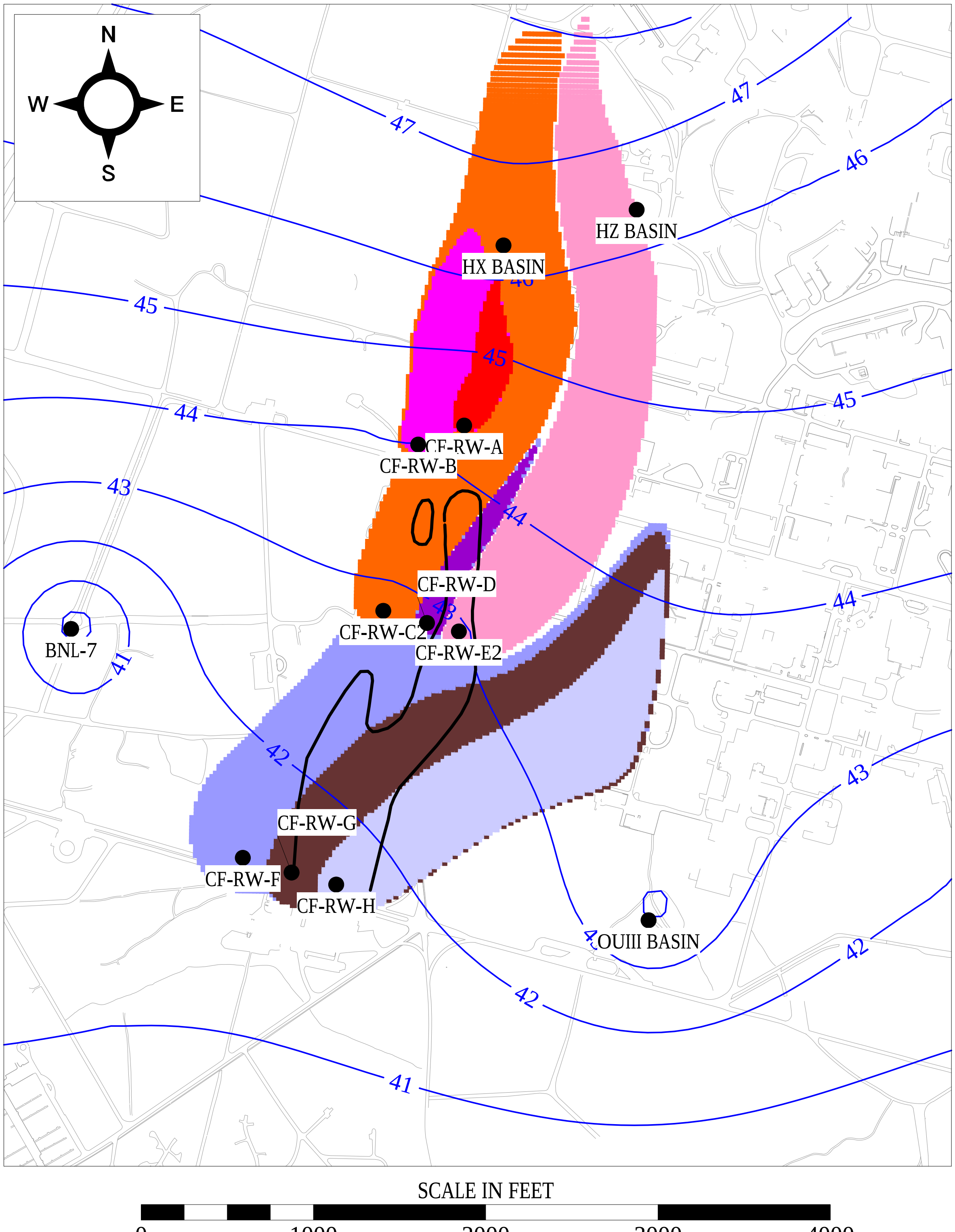
FIGURE
8



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE

CF-RW-B CAPTURE ZONE

CF-RW-C2 CAPTURE ZONE

CF-RW-D CAPTURE ZONE

CF-RW-E2 CAPTURE ZONE

CF-RW-F CAPTURE ZONE

CF-RW-G CAPTURE ZONE

CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 5

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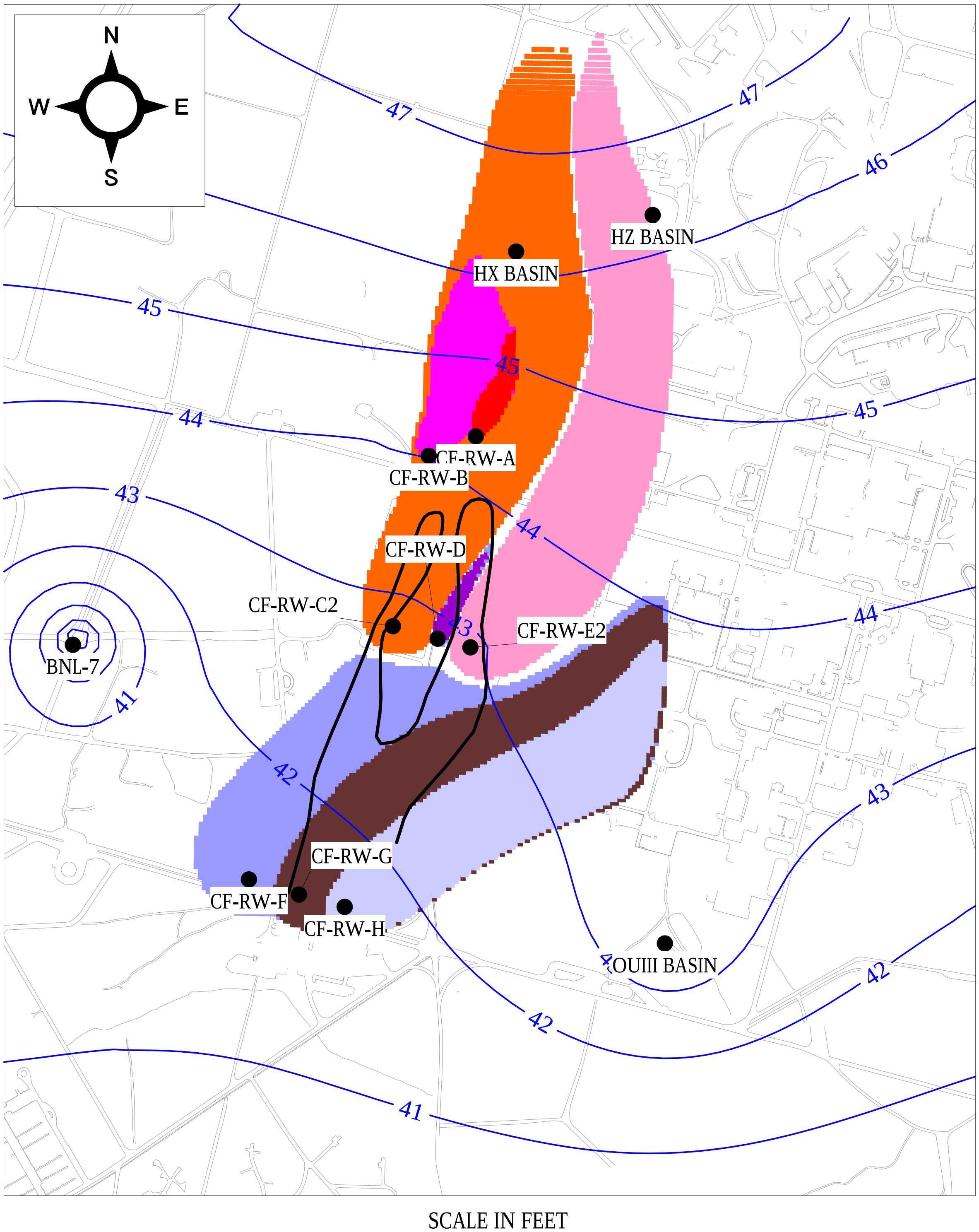
FIGURE
9



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE

CF-RW-B CAPTURE ZONE

CF-RW-C2 CAPTURE ZONE

CF-RW-D CAPTURE ZONE

CF-RW-E2 CAPTURE ZONE

CF-RW-F CAPTURE ZONE

CF-RW-G CAPTURE ZONE

CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 6

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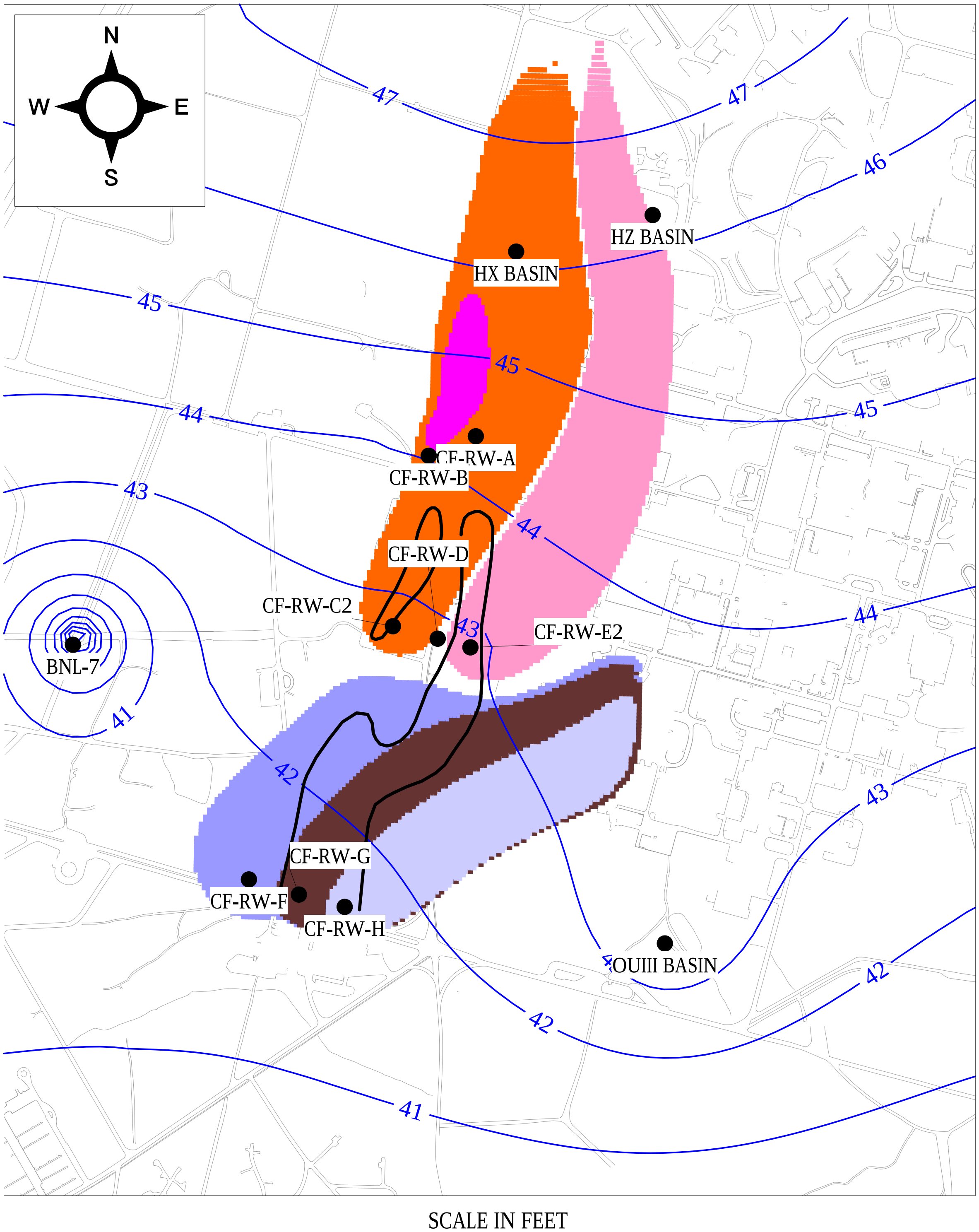
FIGURE
10



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE

CF-RW-B CAPTURE ZONE

CF-RW-C2 CAPTURE ZONE

CF-RW-D CAPTURE ZONE

CF-RW-E2 CAPTURE ZONE

CF-RW-F CAPTURE ZONE

CF-RW-G CAPTURE ZONE

CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 7

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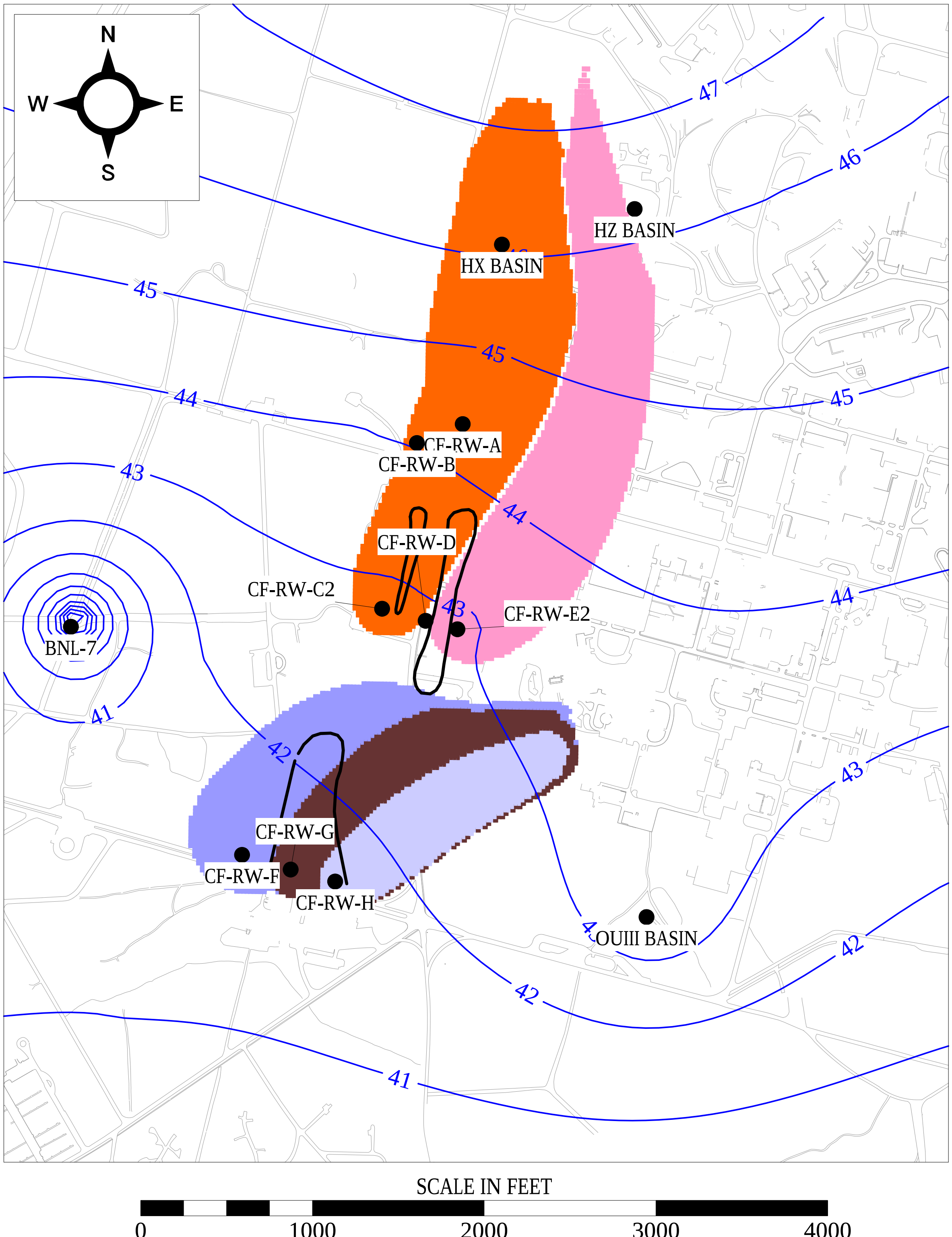
FIGURE

11



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE

CF-RW-B CAPTURE ZONE

CF-RW-C2 CAPTURE ZONE

CF-RW-D CAPTURE ZONE

CF-RW-E2 CAPTURE ZONE

CF-RW-F CAPTURE ZONE

CF-RW-G CAPTURE ZONE

CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 8

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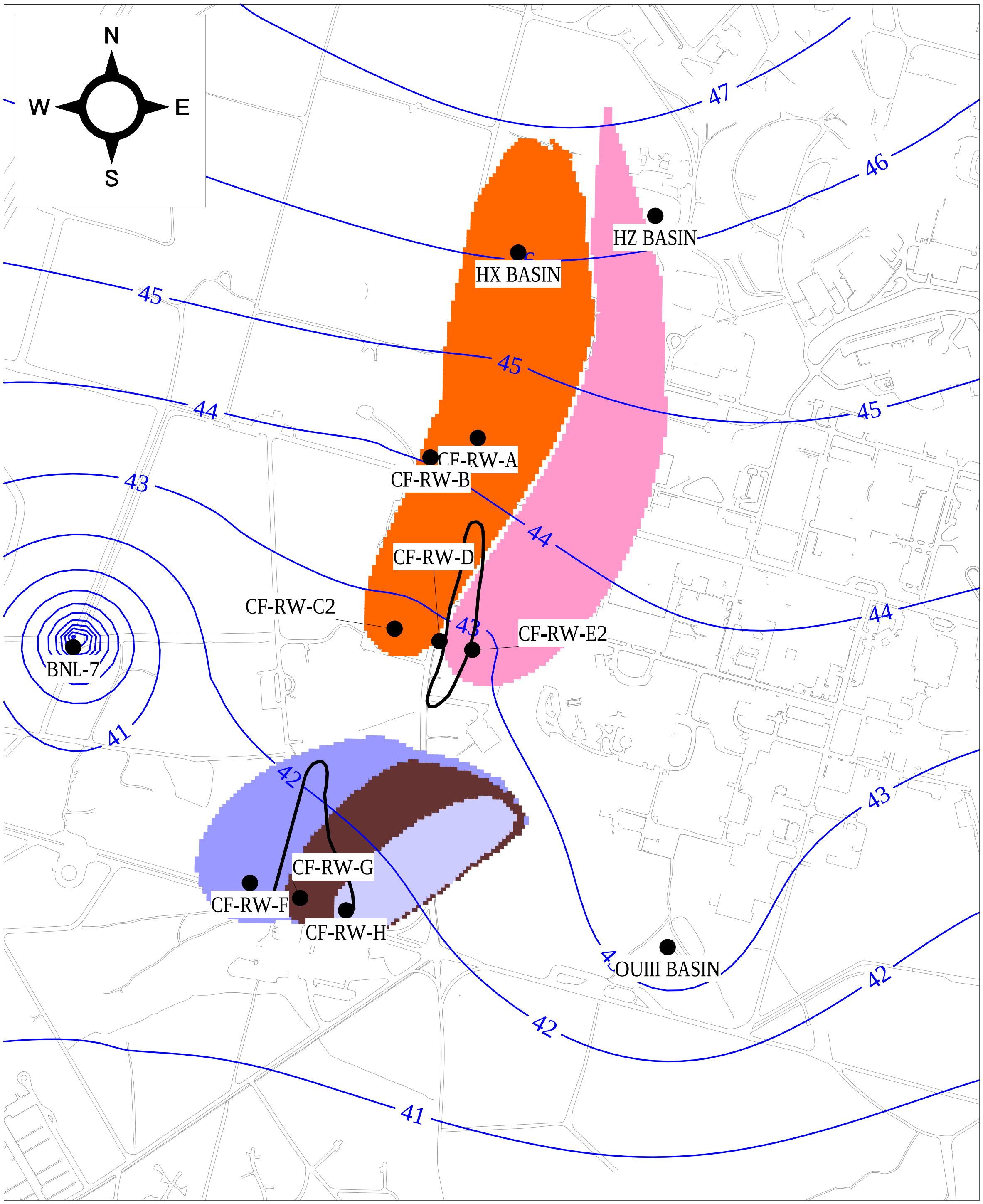
FIGURE
12



SCALE IN FEET

0 1000 2000 3000 4000

41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE
CF-RW-B CAPTURE ZONE
CF-RW-C2 CAPTURE ZONE
CF-RW-D CAPTURE ZONE
CF-RW-E2 CAPTURE ZONE
CF-RW-F CAPTURE ZONE
CF-RW-G CAPTURE ZONE
CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 9

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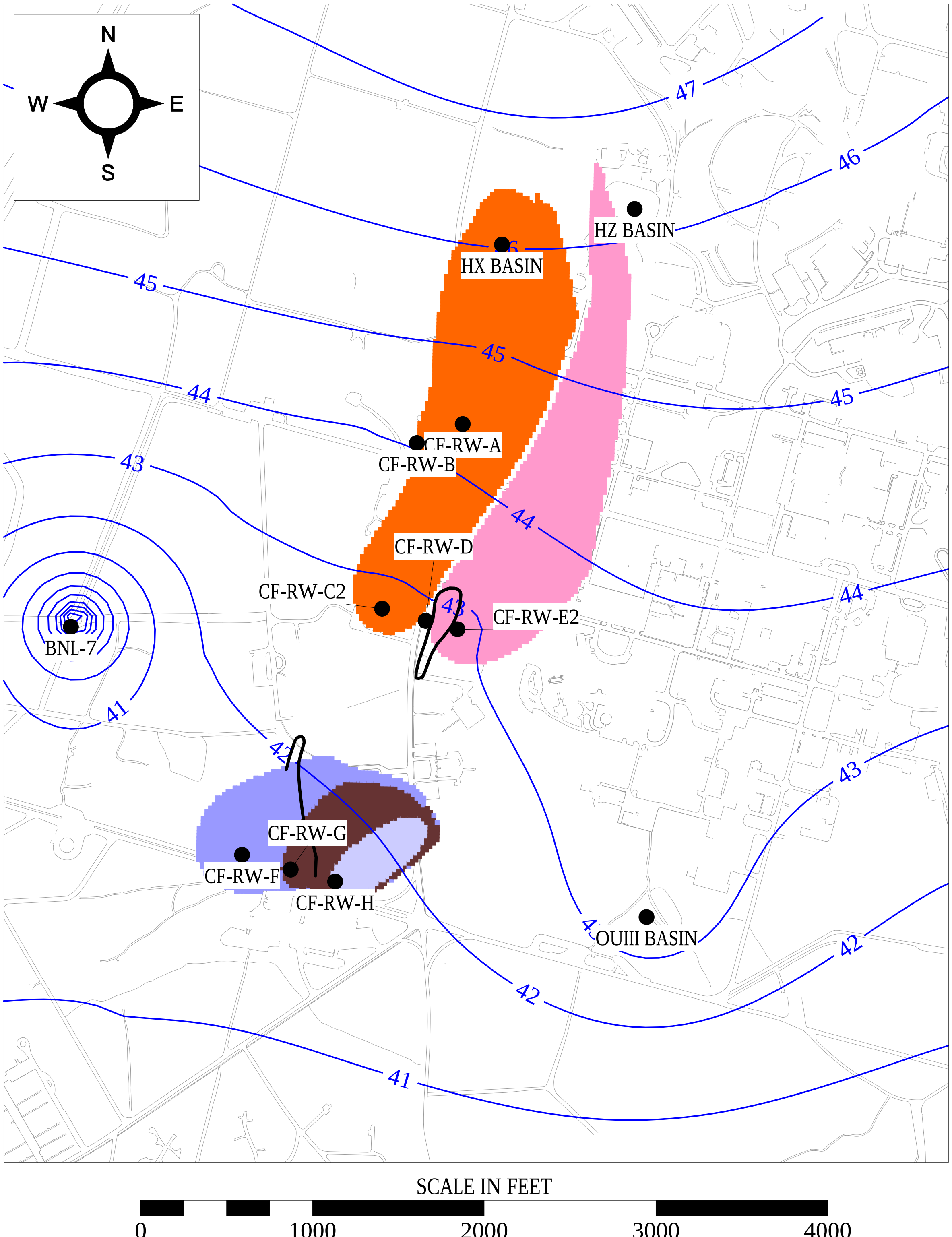
FIGURE
13



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE

CF-RW-B CAPTURE ZONE

CF-RW-C2 CAPTURE ZONE

CF-RW-D CAPTURE ZONE

CF-RW-E2 CAPTURE ZONE

CF-RW-F CAPTURE ZONE

CF-RW-G CAPTURE ZONE

CF-RW-H CAPTURE ZONE

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CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 10

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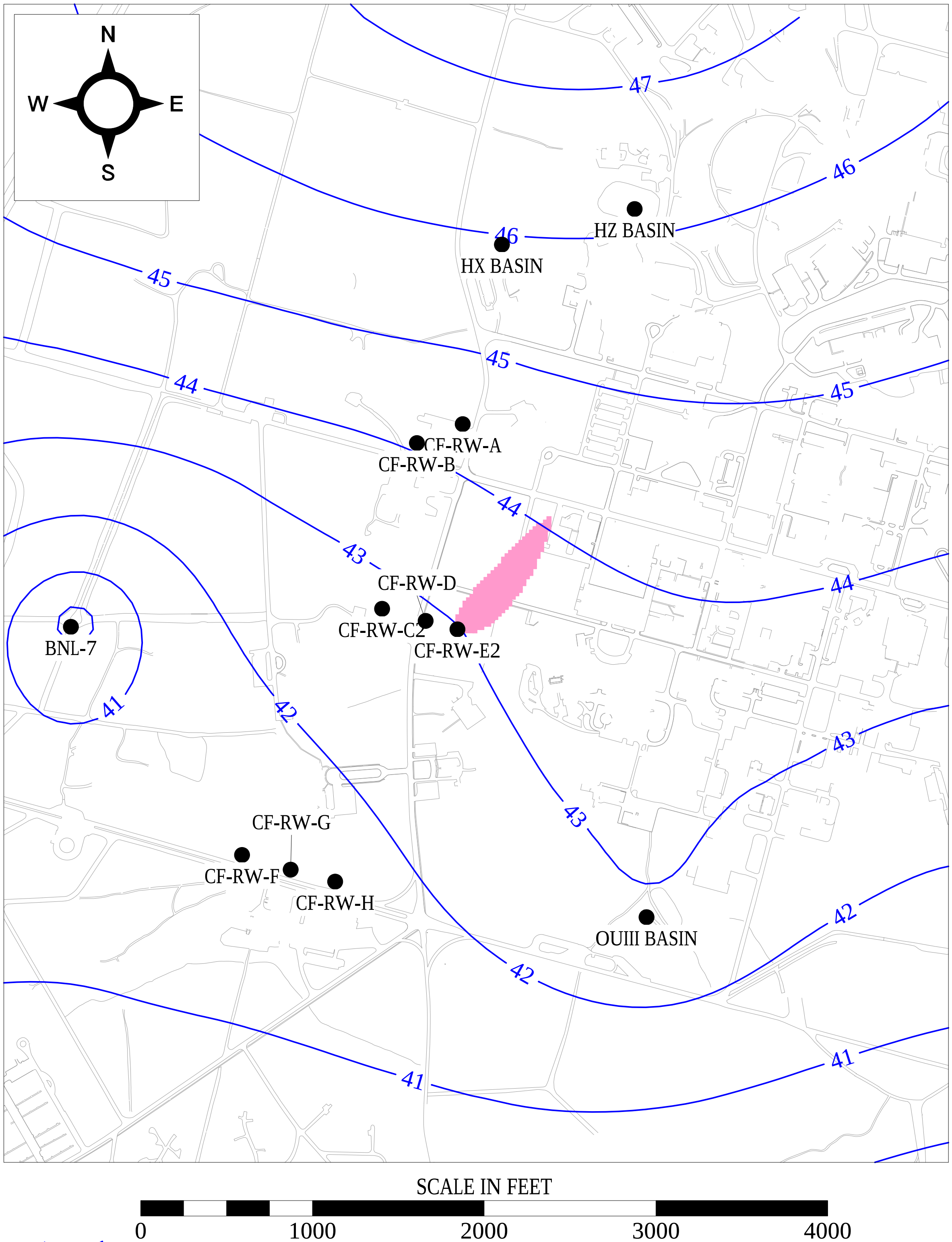
FIGURE

14



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

CF-RW-A CAPTURE ZONE

CF-RW-B CAPTURE ZONE

CF-RW-C2 CAPTURE ZONE

CF-RW-D CAPTURE ZONE

CF-RW-E2 CAPTURE ZONE

CF-RW-F CAPTURE ZONE

CF-RW-G CAPTURE ZONE

CF-RW-H CAPTURE ZONE

PROJECT NAME -

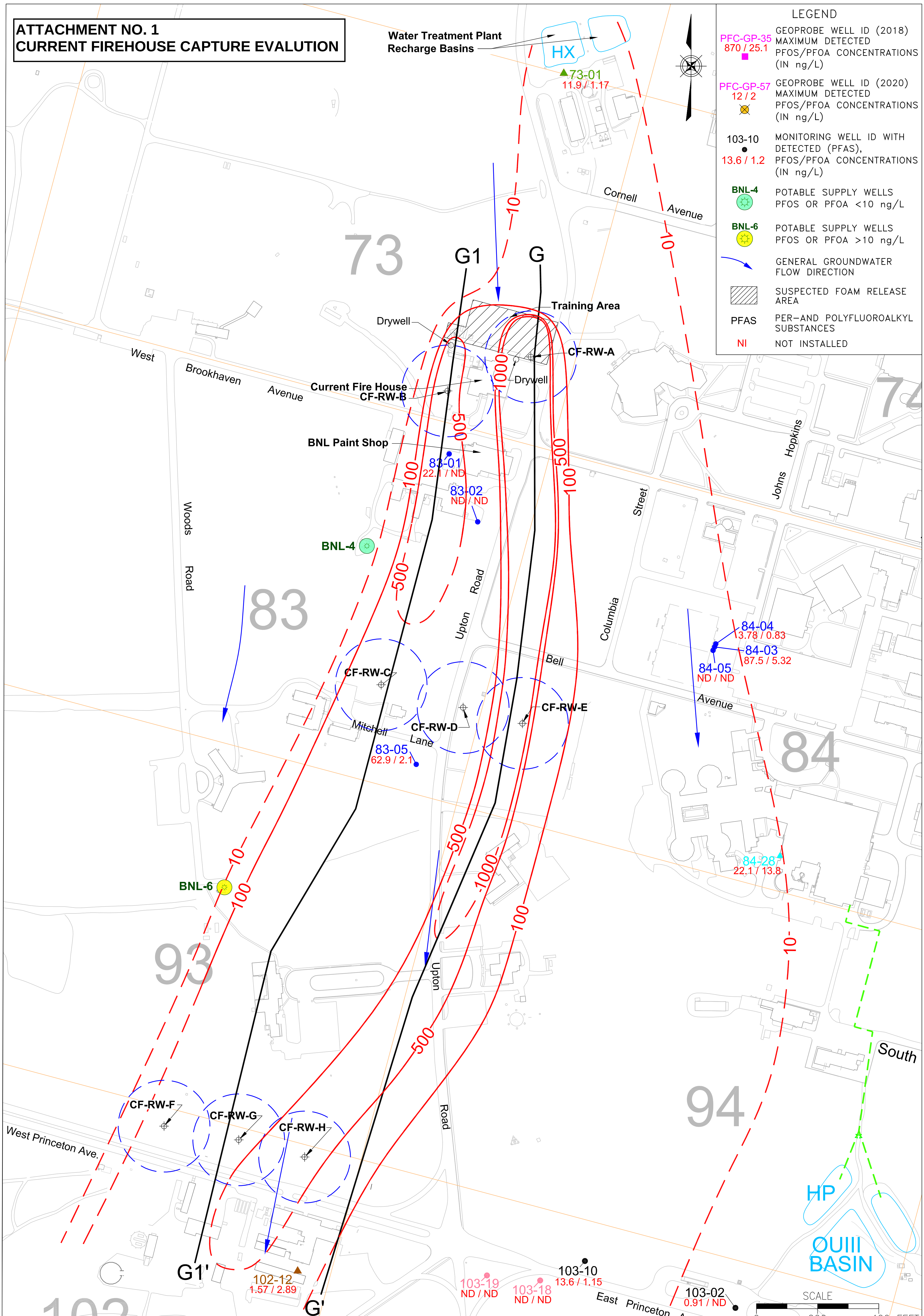
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

CURRENT FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 11

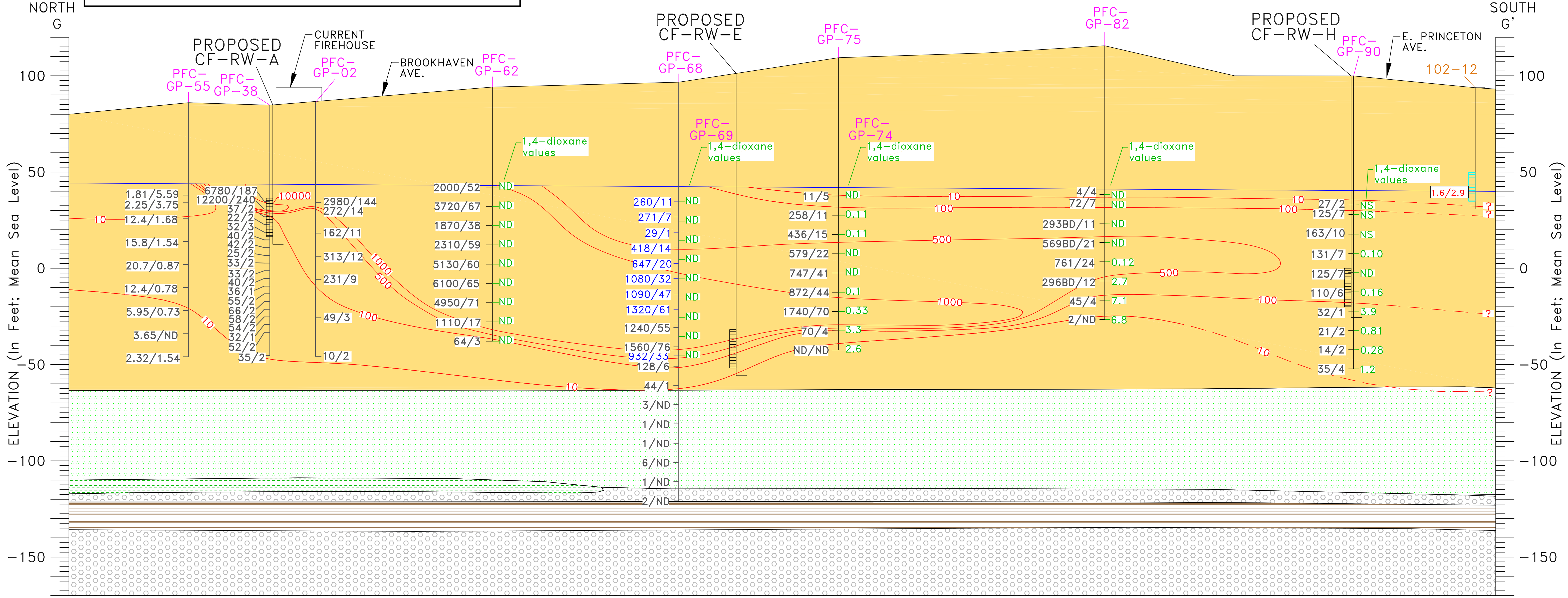
ARCADIS Design & Consultancy for natural and built assets

FIGURE
15



BROOKHAVEN NATIONAL LABORATORY ENVIRONMENTAL PROTECTION DIVISION	TITLE: CURRENT FIREHOUSE PFAS PLUME TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT	DWN: AJZ	VT:HZ.: –	DATE: 06/17/20	PROJECT NO.: –
		CHKD: DEP	APPD: DEP	REV.: 04/05/21	NOTES: –
		FIGURE NO.: 1			

ATTACHMENT NO. 2
CURRENT FIREHOUSE CAPTURE EVALUATION



LEGEND

Upper Glacial aquifer
- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay
- GL Gardiners Clay
- GS Gardiners Clay – Silt

Magothy aquifer
- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undifferentiated)
- MO Magothy – OTHER

HORIZONTAL SCALE
0 500 FEET

102-12 BNL Well ID
PFC-GP-55 Geoprobe Well ID
NS = Well Not Sampled
ND = Not Detected
ND/1.75 PFOS Value/PFOA Value in (ng/L)
—10— ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 – Jan 10, 2020
Monitoring Well Screen
ng/L– Nanograms Per Liter

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 – JANUARY 26, 2021 SAMPLING EVENTS.

3) DATA FOR GP-02 ARE FROM MAY 2018 AND DATA FOR GP-38 ARE FROM NOVEMBER 2018.

4) CONTOUR INTERVAL IS AS SHOWN.

5) BNL WELL ID COLOR CORRESPONDS TO LONG-TERM MONITORING PROGRAM WELL LOCATION MAP.

Q:\2020\BNLab\20-01 EPD\Task 04 PFAS Characterization\Figures\Phase 5\2021-02-18\Fig_10A CF Section G-G' 021121.dwg

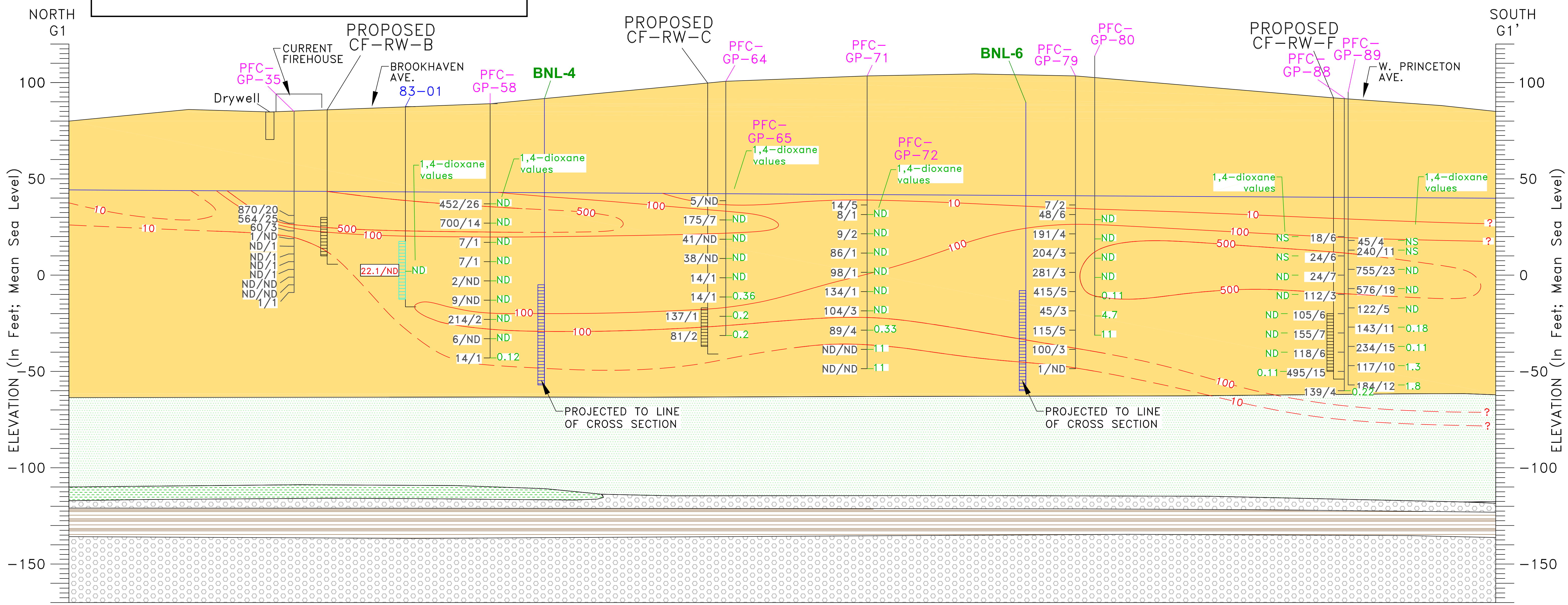
BROOKHAVEN NATIONAL LABORATORY
ENVIRONMENTAL PROTECTION DIVISION

TITLE:
CURRENT FIREHOUSE CROSS SECTION G–G'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 20:1	DATE: 08/18/20	PROJECT NO.: –
CHKD: WRD	APPD: WRD	REV.: 04/15/21	NOTES: –
FIGURE NO.: 2			

ATTACHMENT NO. 3
CURRENT FIREHOUSE CAPTURE EVALUATION



LEGEND

Upper Glacial aquifer

- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay

- GL Gardiners Clay
- GS Gardiners Clay − Silt

HORIZONTAL SCALE

0 500 FEET

Magothy aquifer

- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undifferentiated)
- MO Magothy − OTHER

102−12 BNL Well ID

PFC−GP−35 Geoprobe Well ID

NS = Well Not Sampled

ND = Not Detected

ND/1.75 PFOS Value/PFOA Value in (ng/L)

—10— ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 − Jan 10, 2020

Monitoring Well Screen

ng/L− Nanograms Per Liter

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 − JANUARY 26, 2021 SAMPLING EVENTS.

3) CONTOUR INTERVAL IS AS SHOWN.

4) BNL WELL ID COLOR CORRESPONDS TO LONG−TERM MONITORING PROGRAM WELL LOCATION MAP.

Q:\2020\BNLab\20−01 EPD\Task 04 PFAS Characterization\Figures\Phase 5\2021−02−18\Fig_10B CF Section G1−G1' 021621.dwg

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

CURRENT FIREHOUSE CROSS SECTION G1−G1'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 20:1	DATE: 08/18/20	PROJECT NO.: −
CHKD: WRD	APPD: WRD	REV.: 04/15/21	NOTES: −
FIGURE NO.: 3			

Appendix C
BNL FFH PFAS Capture Evaluation Memo, Arcadis

Memo

SUBJECT	TO
DRAFT - BNL FFH PFAS Capture Evaluation	Bob Holzmacher, J.R. Holzmacher P.E., LLC
DATE	**OUR REF**
April 15, 2021	
DEPARTMENT	**PROJECT NUMBER**
ENVIRONMENT	30066617.00001
COPIES TO	**NAME**
Vincent Racaniello, BNL File	Robert Porsche rporsche@arcadis-us.com

This memo documents the work performed in support of the design of a groundwater pump and treat system for the per- and polyfluoroalkyl substances (PFAS) plume associated with the Former Fire House (FFH) area. Specifically, this memo documents the capture analysis conducted to evaluate the locations and extraction rates of proposed remedial wells. This modeling effort was completed after updating the BNL Regional Groundwater Flow Model. This updated regional model was then used for the development of a new FFH PFAS sub-model. The work was conducted under contract to JR Holzmacher, the engineering firm designing the PFAS remediation system for the FFH.

INTRODUCTION

This modeling effort was performed to evaluate hydraulic capture of PFAS-impacted groundwater emanating from the Former Fire House and focused on designing a remedial well network with the goal of capturing PFAS-impacted groundwater at concentrations of 100 nanograms/Liter (ng/L) or higher. Initial remedial well locations and their associated screen zones were collaboratively developed by JR Holzmacher and BNL personnel; based on the distribution of PFAS-impacted groundwater noted during the recently completed characterization efforts. Figures depicting the distribution of PFAS in the vicinity of the FFH are included with this memo as Attachments 1 and 2. The design of the FFH remedial system includes three remedial wells along the approximate centerline of the highest concentration of the plume. Well FF-RW-A is the furthest to the north and is the shallowest of the wells, FF-RW-B is approximately mid-way between FF-RW-A and FF-RW-C, and FF-RW-C is the southernmost well and has the deepest well screen interval of the three.

This work was conducted in support of the Groundwater Protection Group of BNL's Environmental Protection Division's remedial design efforts, with Arcadis working under contract to JR Holzmacher, the remedial system design engineers. The modeling software Groundwater Vistas (Version 7.24 Build 70), a graphical user interface which serves as a pre- and post-processor for MODFLOW (McDonald, 1988) and MODPATH (Pollack, 1994), was used to develop the FFH PFAS sub-model, update hydraulic parameters and boundary conditions, and delineate the FFH PFAS plume. MODFLOW is the U.S. Geological Survey's modular finite-difference flow model and is used to simulate groundwater flow. MODPATH is a particle tracking post-processing package developed to compute three-dimensional flow paths using output from steady-state or transient groundwater flow simulations completed with MODFLOW.

KEY ASSUMPTIONS AND MODEL MODIFICATIONS

The FFH PFAS flow and particle tracking simulations described herein were conducted using a purpose-built sub-model, derived from the recently updated regional groundwater flow model.

The following key assumptions were made for this modeling effort:

- Properties and boundary conditions in the sub-model were inherited from the recently calibrated and updated Regional Groundwater Flow Model (Arcadis, 2020). **Figure 1** shows the layers of the sub-model and the associated horizonal hydraulic conductivities assigned to the sub-model layers.
- Aerial extent of sub-model:
    - Approximately 7,300 ft in the east-west direction.
    - Approximately 10,400 ft in the north-south direction.
- Both the RA-V basin and the Operable Unit III (OU-III) basin are represented within the sub-model extent. During this evaluation, simulated recharge rates applied to these basins were adjusted to account for flow from the proposed Current Fire House (CFH) treatment system and the proposed Former Fire House treatment system.
- Following extraction of the sub-model, layers 1 and 2 were divided into 10 layers, with each layer having a thickness of 12 ft in the area downgradient of the FFH.
- There were no changes made to the sub-model which would alter flow directions or rates of flow predicted by the regional flow model. No changes were made to aerial recharge rates or boundary flow conditions.
- Groundwater flow and transport were simulated under steady state conditions.

SUB-MODEL DEVELOPMENT

The sub-model was developed using a process called telescopic mesh refinement (TMR), which enables the development of a sub-model from a larger model while preserving the model parameters, structure, and boundary conditions.

TMR is a well-accepted method for developing sub-models or simply refining more regional scale models in an area of interest. Arcadis developed a simple FORTRAN utility which enables the user to easily create a new model that inherits the properties and boundary conditions from the parent or regional model.

TMR was used to extract a portion of the regional groundwater flow model and modify model grid cell sizes and the discretization of what was formerly regional model layers 1 and 2.

The sub-model includes all eight layers from the regional groundwater flow model, reconfigured as follows:

- Regional model layers 1 and 2 correspond to sub-model layers 1 through 4 and 5 through 10, respectively; with each layer having a thickness in the sub-model of 12 ft.
- Regional model layers 3 through 8 correspond to sub-model layers 11 – 16; the thickness of these layers in the sub-model are unchanged from the regional model.

Sub-Model Discretization

Following development of the sub-model, model layers 1 and 2 were modified by splitting each layer into four and six layers respectively; **see Figure 1**. This was done to enhance the vertical discretization for the purposes of evaluating the vertical movement of the FFH PFAS plume and enabling optimization of the proposed remedial well screens. Following this revision, layers 1 through 10 were each 12-ft thick.

In addition, the model grid was modified to reduce model cell sizes from 100 ft by 100 ft in the regional groundwater flow model to 20 ft by 20 ft in the sub-model over the area of interest.

Model grid and boundary conditions are shown on **Figure 2**.

GROUNDWATER FLOW FIELD

The sub-model's groundwater flow field was derived from the recently updated BNL Regional Groundwater Flow Model. The extracted sub-model is bounded by constant head cells (**Figure 2**). The potentiometric surface of the water table within the sub-model under non-pumping conditions (i.e., no FFH PFAS remedial wells pumping) is shown on the left-hand panel of **Figure 3**. The right-hand panel of Figure 3 shows the potentiometric surface under the influence of the FFH PFAS remedial system, which will be discussed in greater detail below.

The left-hand panel indicates that groundwater in the vicinity of the FFH is flowing to the south, under the local influence of recharge from the RA-V and OU-III recharge basins, with water table elevations ranging from about 46 ft above mean sea level (MSL) near the FFH, to about 33 ft MSL at the southern extent of the sub-model. These water level elevations are identical to the water table elevations predicted by the regional groundwater flow model over the area of the sub-model. Hydraulic capture of the FFH PFAS plume was simulated under steady state groundwater flow conditions.

The two panel display of the water table under pre-remediation and remediation conditions demonstrates the impact of the proposed FFH PFAS remedial system on local groundwater flow.

DISCUSSION OF MODEL SIMULATION AND RESULTS

The evaluation and optimization of hydraulic capture achieved by the proposed remedial well network was completed through an iterative process of testing the impact of anticipated minimum and maximum pumping rates assigned to the 3 proposed remedial wells, then varying the assigned pumping rates for the wells to achieve capture of the 100 ng/L FFH-PFAS plume.

Forward Particle Tracking

The potential movement of the FFH PFAS plume was evaluated by conducting a forward particle tracking simulation under pre-remediation conditions (i.e., the proposed FFH PFAS containment system was not active). **Figure 4** shows the configuration of the pre-remediation water table, along with the predicted pathlines for particles released in model layer 1, beginning around the area of the FFH and travelling south.

The simulation tracked the model-predicted movement of the particles. The colors of the particle pathlines indicate the model layers through which the particles are travelling during the simulation.   For the purposes of this evaluation, pathlines were truncated after 15 years. The arrowheads along each pathline mark 5 years of travel time (calculated with an aquifer porosity of 15%).

HYDRAULIC CAPTURE ANALYSIS

The following sections describe the proposed remedial well layout, the development of the proposed remedial well pumping rates and the results of the hydraulic capture analysis.

The primary goal of this groundwater modeling exercise was to use the model to develop a proposed remedial well network which would mitigate the continued downgradient movement of the FFH-PFAS plume at concentrations above 100 ng/L. The capture analysis was an iterative process during which 3 capture assessment scenarios were simulated under various combinations of pumping rates. The results presented here describe the final capture simulation, which achieved the goals of the design effort by preventing the continued movement of dissolved PFAS at concentrations above 100 ng/L.

Simulated Pumping Rates

As originally proposed, the FFH PFAS remedial well network consisted of three remedial wells (FF-RW-A, FF-RW-B, and FF-RW-C) along the centerline of the highest concentration of the plume, with the shallowest well located in the north and the deepest well at the southern end of the plume.

Various combinations of pumping rates were evaluated during the development of the proposed remedial well network. The evaluation considered system-wide flow rates ranging from 145 gpm to 225 gpm. The pumping rates and screen zones associated with the final capture simulation are summarized on **Table 1**. In addition, an alternate well configuration, with FF-RW-B pumping at 50 gpm, and FF-RW-A and -B pumping at the rates indicated on Table 1 also achieves capture. However, operating the FF-RW-B at 75 gpm was selected as the preferred configuration because it may offer some additional assurance of capturing the entire plume at this location. All remedial wells were simulated with 20-ft long screens. Simulated pumping rates across the well network ranged from 50 - 100 gallons per minute (gpm), with the simulated system having a total pumping rate of 250 gpm.

Treated discharge from the FFH PFAS remedial well network will be returned to the aquifer through the RA V basin. During the iterative evaluation, the recharge rates of the RA-V and OU-III recharge basins were constrained based on input from BNL facilities staff. The base recharge rates for RA-V and OU-III respectively were 263 gpm and 448 gpm.

Both rates were then adjusted to account for inflow from the Current Fire House (CFH) remediation system. The treated discharge from the CFH remedial system will be discharged to the OU III basin network, which currently receives water from the Middle Road, South Boundary and Western South Boundary remedial systems (MR/SR/WSB). However, discharge from the MR/SR/WSB systems enters the OU III basin network via a wet well, which can divert approximately 300 gpm from the OU III basins to the RA V basins. The CFH is anticipated to treat about 360 gpm, all of which will be returned to the aquifer through the OU III basins. However, to mitigate the impact of this additional recharge on the local groundwater flow field, the wet well will be used to divert 300 gpm from the MR/SR/WSB systems to the RA V basin network. For the purposes of this modeling evaluation, operation of the CFH is expected to result in the addition of 60 gpm to the OU III basin network, and 300 gpm to the RA V basin network.

To evaluate the FFH PFAS system, the recharge rate for RA-V was varied based on the FFH simulated PFAS remedial well network's production; under the proposed remedy, 225 gpm will be returned to the aquifer through the RA V basin network.

Sensitivity Analysis

During the iterative capture analysis, the simulated pumping rates for BNL extractions wells RTW-1 and RTW-3 associated with the Building 96 remedial system were 40 and 21 gpm, respectively, which are their assigned rates in the regional groundwater flow model. As requested by BNL since this is the current pumping scenario being used at Building 96, a simulation was conducted to assess the impact of RTW-1 operating at its peak rate of 60 gpm; for this sensitivity assessment RTW-3 was turned off. A review of the model predicted capture with RTW-1 pumping at 60 gpm and RTW-3 turned off, indicated that the model predicted capture was essentially equivalent to the extent of capture presented in **Figures 5 – 15**.

Simulated Treatment System Discharge

Based on discussions with BNL, it is anticipated that up to 300 gpm from the MR/SB/WSB remedial systems will be diverted from the OU III basin network to the RA V basin network. The CFH remedial system's treated water discharge will be returned to the aquifer through the OU III basin network.

For each capture scenario evaluated for the FFH PFAS plume area, the simulated treated water discharge from the FFH remedial system was returned to the aquifer via the RA-V basin. For the final capture simulation, 225 gpm was recharged to the aquifer from the FFH system.

Proposed Remedial Well Layout

The proposed layout of the remedial well network is shown in the right-hand panel of **Figure 3**; the right-hand panel also shows the impact of the remedial well network on local groundwater flow.

Under pre-remediation conditions (shown on the left-hand panel of Figure 3) the water table contours exhibit a southerly trend in groundwater flow. This tendency for southerly flow is minimally affected by the operation of the FFH-PFAS remedial well network, and the associated additional recharge at both the RA-V and the OU-III basin (shown on the right-hand panel of Figure 3).

Endpoint Analysis

The extent (vertically and horizontally) of the capture zone resulting from the operation of the proposed FFH PFAS remedial well network was determined through an endpoint analysis. For this analysis, a "cloud" of particles is released throughout the model area, such that particles are started within each model cell over an area that encompasses and extends beyond the limits of the portion of the aquifer targeted for capture (i.e., the 100 ng/L PFAS plume).

Under the simulated groundwater flow field resulting from the operation of the remedial well network and the local recharge of groundwater to the RA-V and OU-III basins, particles are tracked from their starting point to their endpoint. When a particle's starting location corresponds to an ending location at one of the FFH PFAS remedial wells, the starting location is marked with a solid color fill. The resulting figure uses fills of different colors to show the capture zones associated with each of the proposed remedial wells. **Figures 5 - 15** show the model predicted capture zones associated with the FFH PFAS remedial well network, in model layers 1 through 11, respectively. On each figure the model predicted capture zones of the remedial wells are identified with a unique color fill.

In aggregate, the area of capture established by the FFH PFAS remedial well system is predicted to capture the 100 ng/L PFAS plume.

CONCLUSIONS

The results of this modeling effort suggest that hydraulic containment of the majority of the FFH PFAS plume at concentrations of 100 ng/L or higher can be achieved with a network of 3 remedial wells, pumping (in total) 225 gpm, and returning the treated water to the aquifer through the RA-V recharge basin. This configuration results in optimized capture of the FFH PFAS plume; the area of hydraulic capture is focused to encompass the extent of the PFAS plume while limiting any superfluous extent of capture.

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Arcadis, 1999 Regional Groundwater Model Update, Brookhaven National Laboratory, Upton, New York. Prepared for Brookhaven National Laboratory, Brookhaven Science Associates. July 30, 1999

Arcadis, 2020 Summary of Groundwater Modeling Work Completed under Task Order 1, Upton, New York. October 27, 2020.

McDonald, Michael G. and Arlen W. Harbaugh. 1988. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model. Techniques of Water-Resources Investigations of the United States Geological Survey, Chapter A1.

Pollack, David W. 1994. User's guide for MODPATH/MODPATH-Plot, Version 3; a particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model. Open-File Report 94-464.

Table 1.
Summary of Simulated Pumping Rate and Well Screen Zone
Former Fire House PFAS Capture
Brookhaven National Laboratory
Upton, New York.

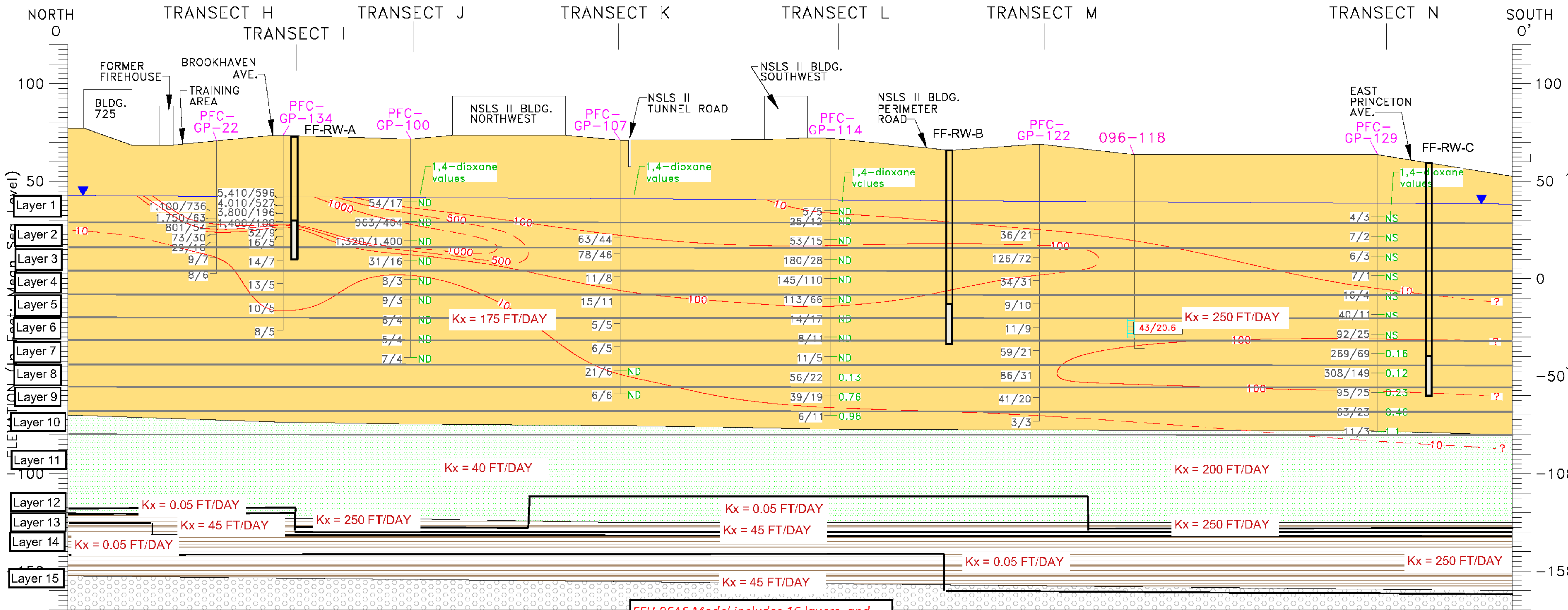
Well ID	Pumping Rate (gpm)	Elevation Screen Top (ft msl)	Elevation Screen Bottom (ft msl)	Screen Length (ft)	Model Layers Screened
FF-RW-A	50	29	9	20	1, 2, 3
FF-RW-B	75	-13	-33	20	5, 6, 7
FF-RW-C	100	-44	-64	20	7, 8, 9

Total Flow: **225**

gpm – gallons per minute

ft – feet

ft msl – feet relative to mean sea level



LEGEND

Upper Glacial aquifer
- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay
- GL Gardiners Clay
- GS Gardiners Clay – Silt

Magothy aquifer
- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undifferentiated)
- MO Magothy – OTHER

096-118 BNL Well ID
PFC-GP-22 Geoprobe Well ID
NS = Well Not Sampled
ND = Not Detected
ND/1.75 PFOS Value/PFOA Value in (ng/L)
—10— ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 – Jan 10, 2020
Monitoring Well Screen
ng/L– Nanograms Per Liter

HORIZONTAL SCALE
0 500 FEET

NOTES:
1. GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g. HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

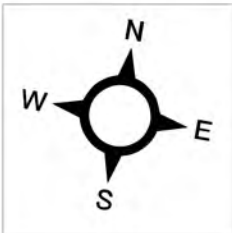
NOTES (continued):
2. PFOS/PFOA RESULTS BASED ON JULY 13, 2020 - JANUARY 26 2021 SAMPLING EVENTS.
3. CONTOUR INTERVAL IS AS SHOWN.
4. BNL WELL ID COLOR CORRESPONDS TO LONG-TERM MONITORING PROGRAM WELL LOCATION MAP.

BROOKHAVEN NATIONAL LAB

FORMER FIREHOUSE AREA SUBMODEL CROSS-SECTION

ARCADIS Design & Consultancy for natural and built assets

FIGURE 1



PROJECT NAME -

SCALE IN FEET

0 1000 2000 3000 4000

CONSTANT HEAD BOUNDARY

MODEL GRID CELL SIZES RANGE FROM
100 FT BY 100 FT TO 20 FT BY 20 FT

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

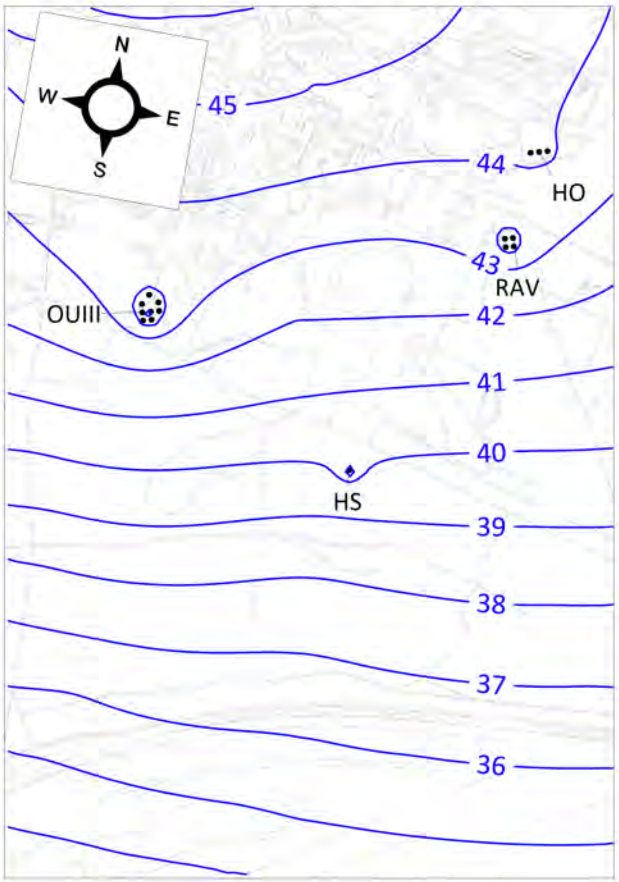
SUB-MODEL GRID AND
BOUNDARY CONDITIONS

ARCADIS Design & Consultancy for natural and built assets

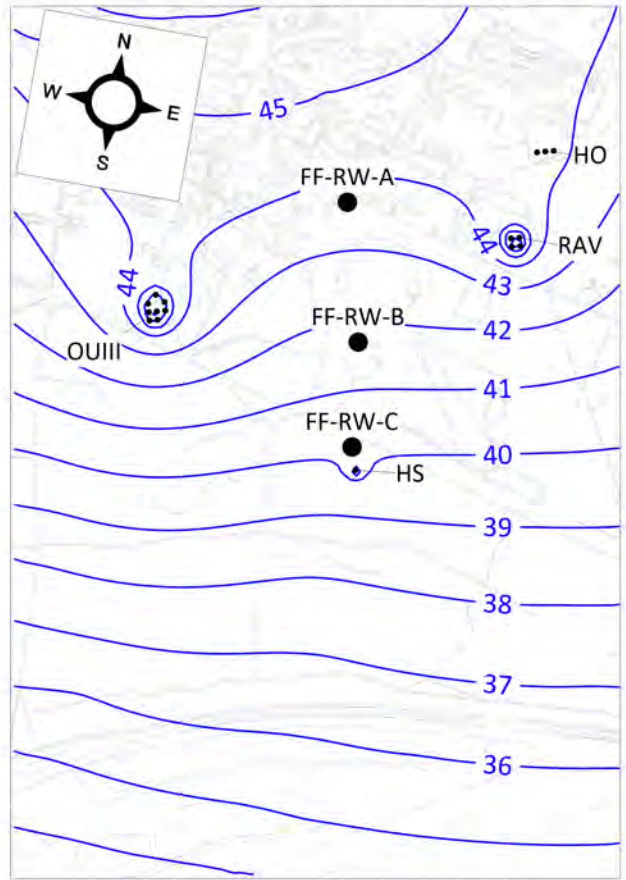
FIGURE

2

PRE-REMEDIATION WATER TABLE



MODEL PREDICTED WATER TABLE



SCALE IN FEET

0 1000 2000 3000 4000

41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

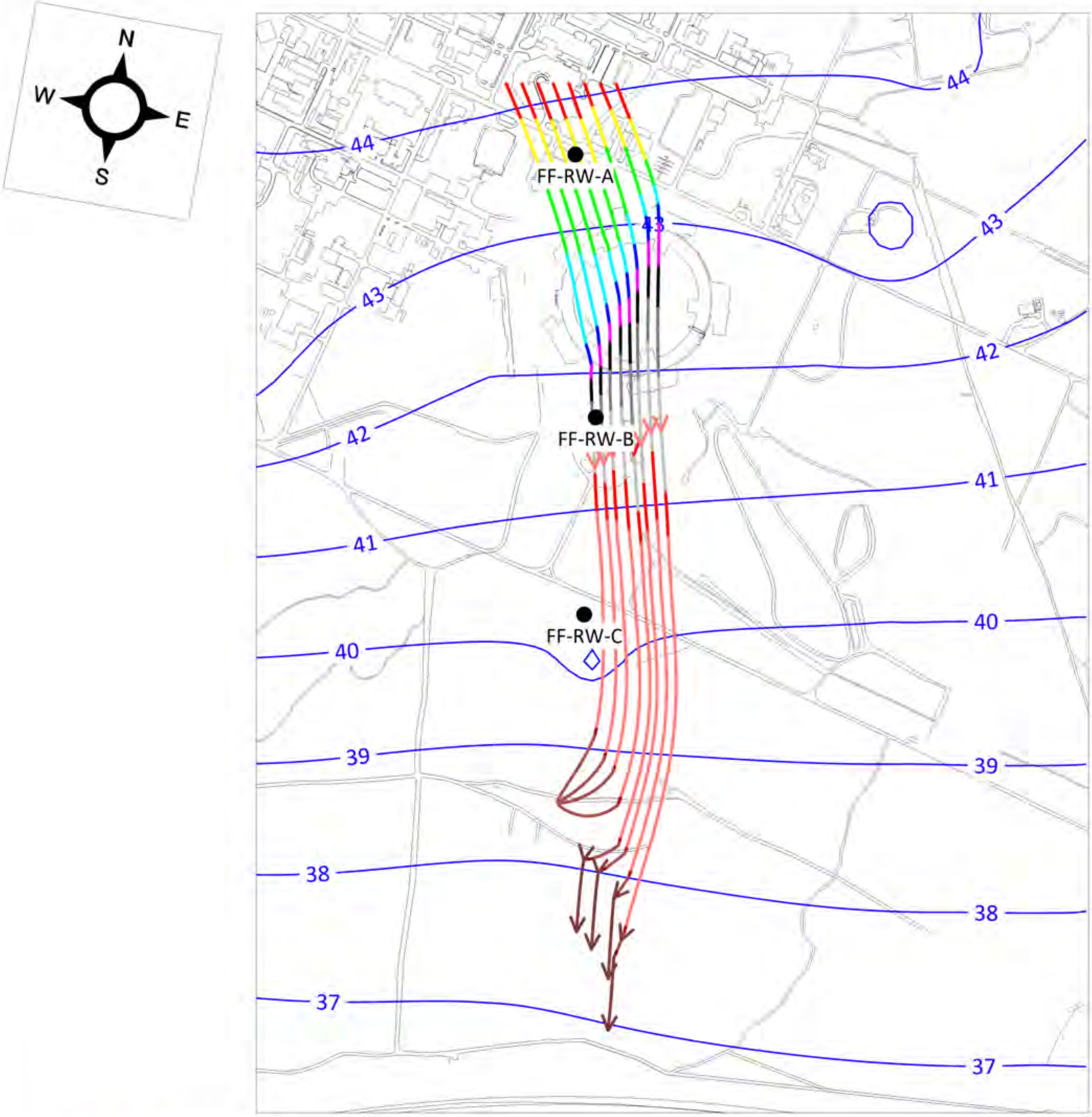
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK
FORMER FIRE HOUSE PFAS CAPTURE

PRE-REMEDIATION AND MODEL-PREDICTED WATER TABLE CONFIGURATION

ARCADIS Design & Consultancy for natural and built assets

FIGURE 3

PROJECT NAME:



POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

PARTICLE PATH IN MODEL LAYER 1
PARTICLE PATH IN MODEL LAYER 2
PARTICLE PATH IN MODEL LAYER 3
PARTICLE PATH IN MODEL LAYER 4
PARTICLE PATH IN MODEL LAYER 5
PARTICLE PATH IN MODEL LAYER 6
PARTICLE PATH IN MODEL LAYER 7
PARTICLE PATH IN MODEL LAYER 8
PARTICLE PATH IN MODEL LAYER 9
PARTICLE PATH IN MODEL LAYER 10
PARTICLE PATH IN MODEL LAYER 11
PARTICLE PATH IN MODEL LAYER 12
ARROWHEAD INDICATES 5 YEARS TRAVEL

SCALE IN FEET

0 1000 2000 3000 4000

PROJECT NAME -

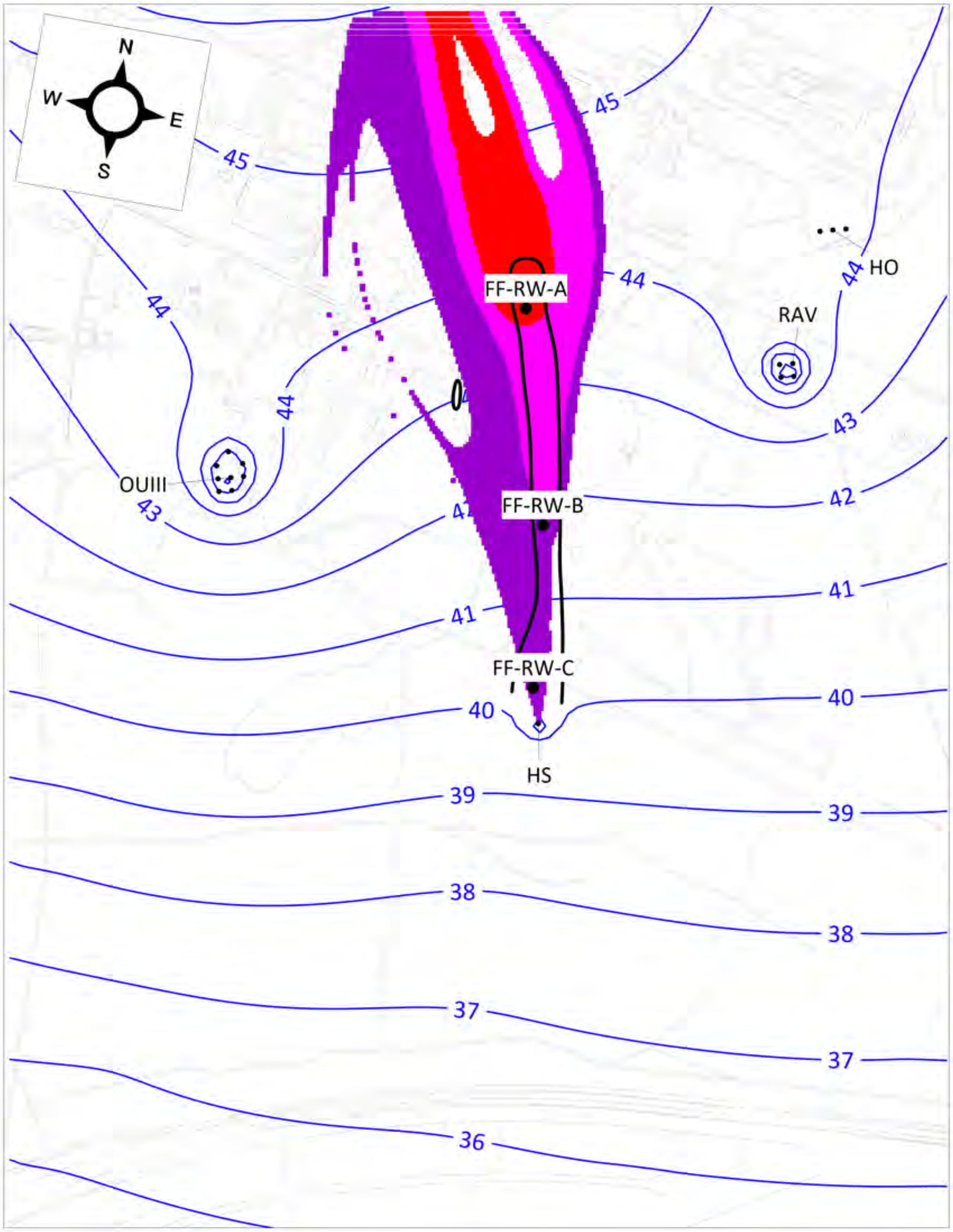
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FOMRER FIRE HOUSE PFAS CAPTURE

PRE-REMEDIATION WATER TABLE CONFIGURATION AND PARTICLE FLOW PATHS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
4



SCALE IN FEET

0 1000 2000 3000 4000

41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

FF-RW-A CAPTURE ZONE

FF-RW-B CAPTURE ZONE

FF-RW-C CAPTURE ZONE

PROJECT NAME -

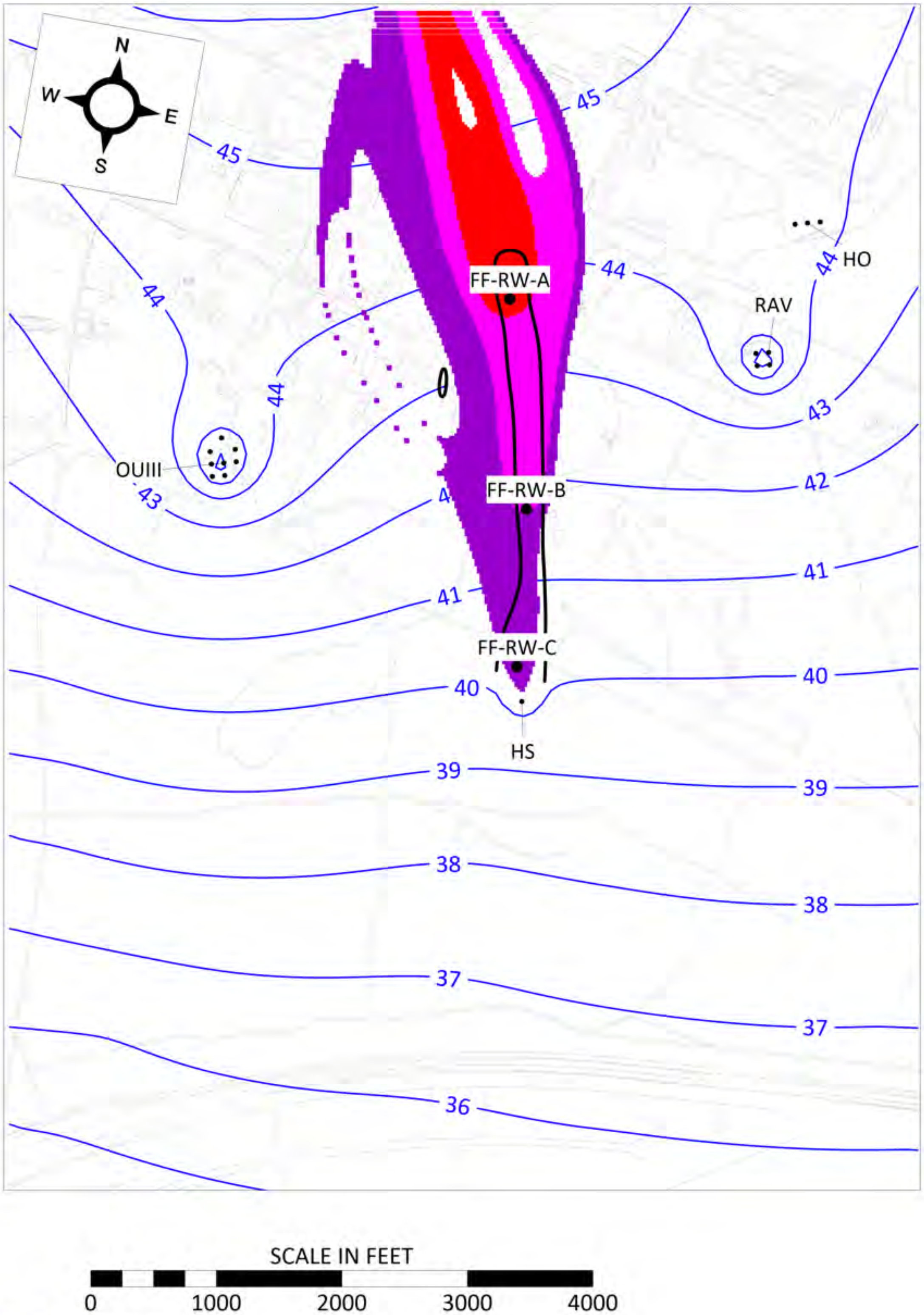
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 1

ARCADIS Design & Consultancy for natural and built assets

FIGURE
5



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

FF-RW-A CAPTURE ZONE

FF-RW-B CAPTURE ZONE

FF-RW-C CAPTURE ZONE

PROJECT NAME -

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

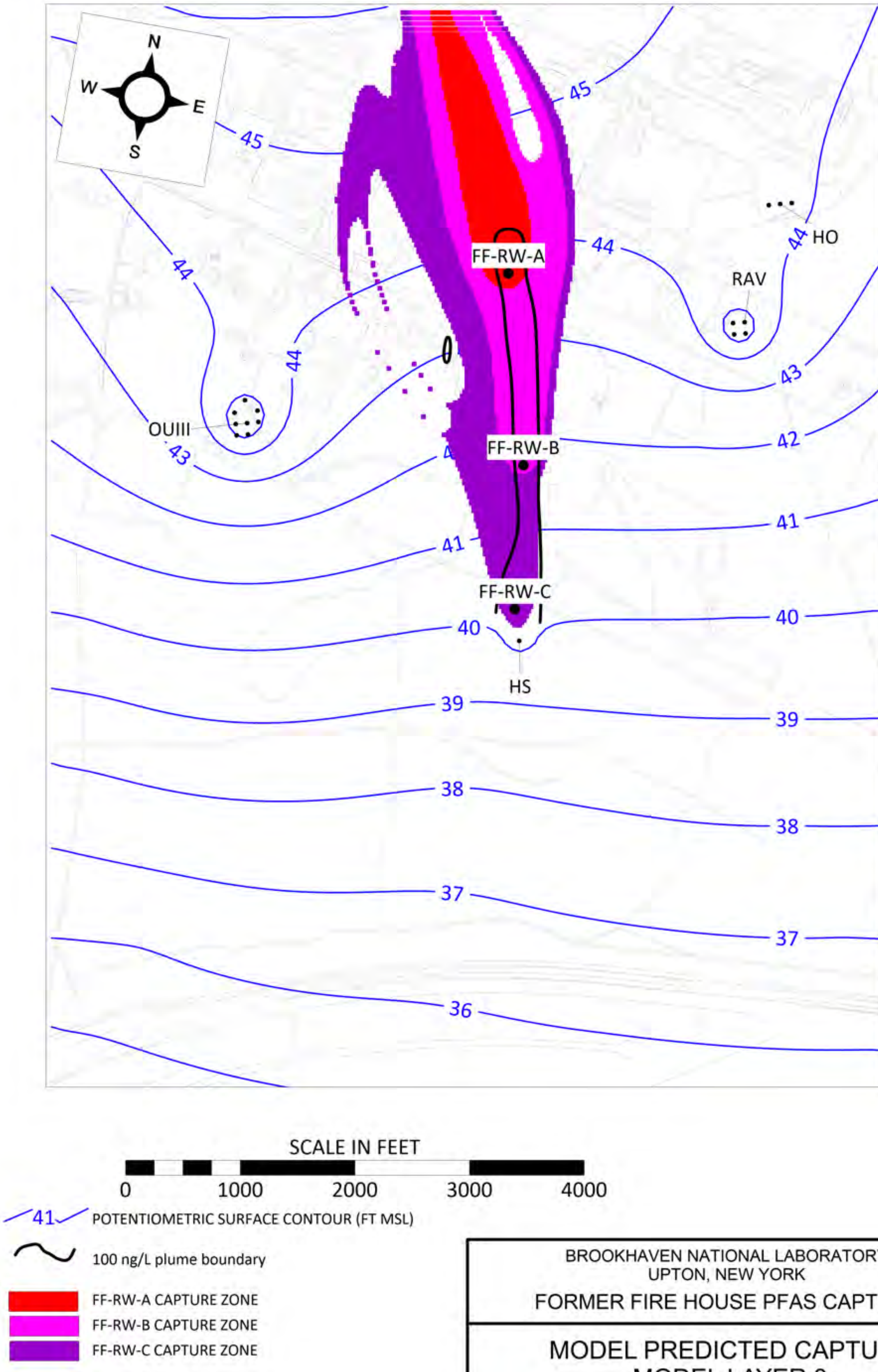
FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 2

ARCADIS Design & Consultancy for natural and built assets

FIGURE

6



PROJECT NAME -

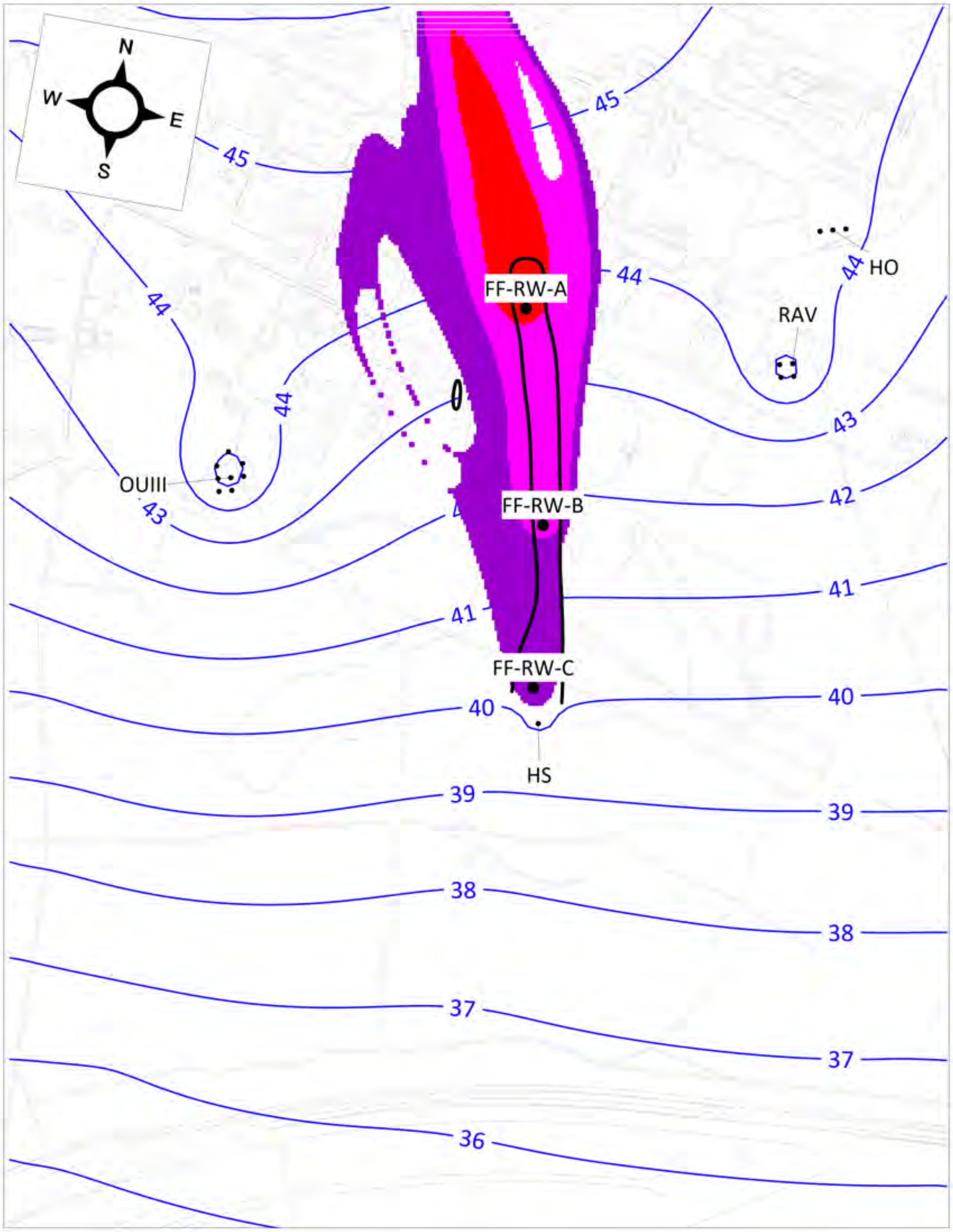
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 3

ARCADIS Design & Consultancy for natural and built assets

FIGURE 7



SCALE IN FEET

0 1000 2000 3000 4000

41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

FF-RW-A CAPTURE ZONE

FF-RW-B CAPTURE ZONE

FF-RW-C CAPTURE ZONE

PROJECT NAME -

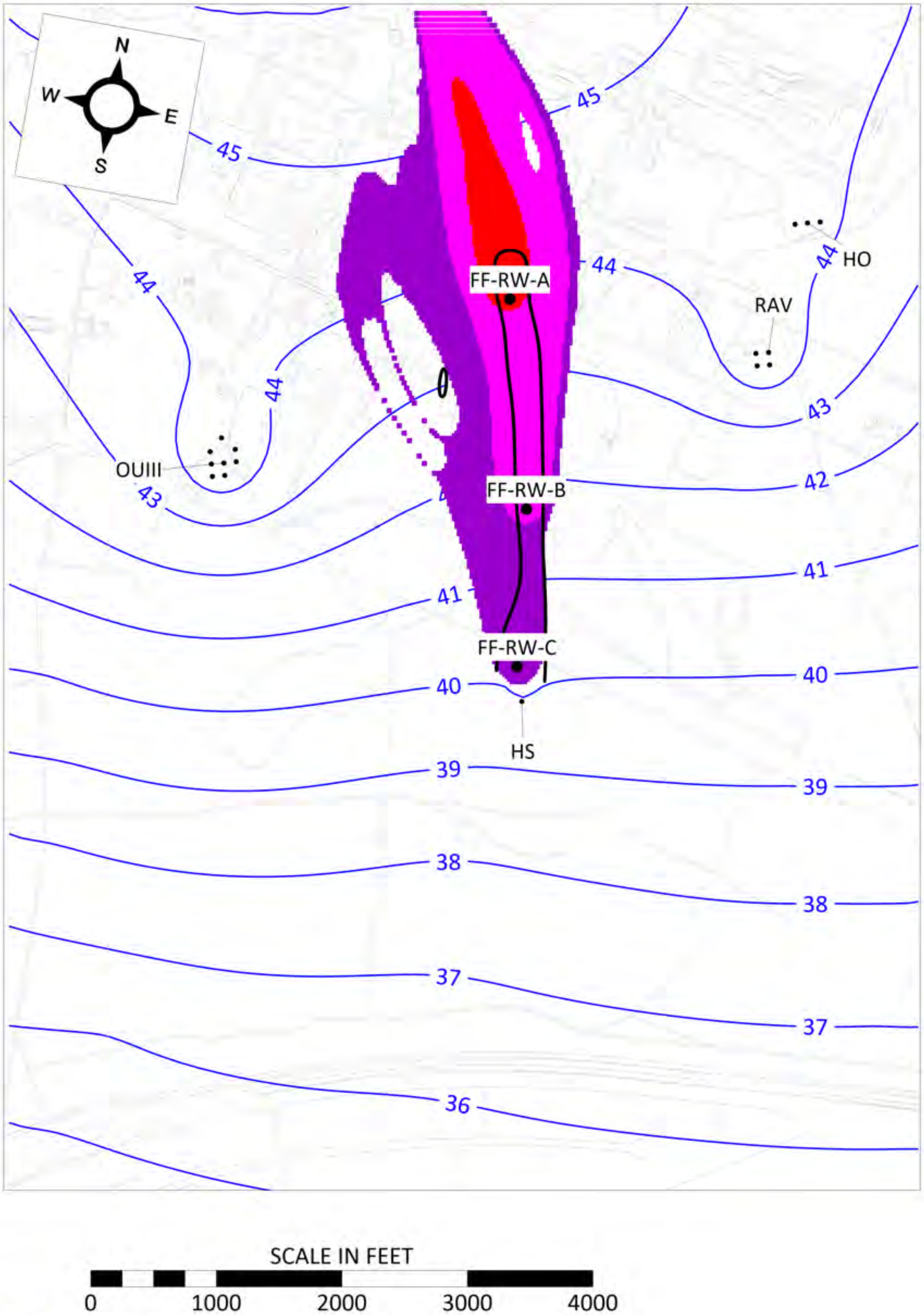
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 4

ARCADIS Design & Consultancy for natural and built assets

FIGURE 8



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

FF-RW-A CAPTURE ZONE

FF-RW-B CAPTURE ZONE

FF-RW-C CAPTURE ZONE

PROJECT NAME -

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

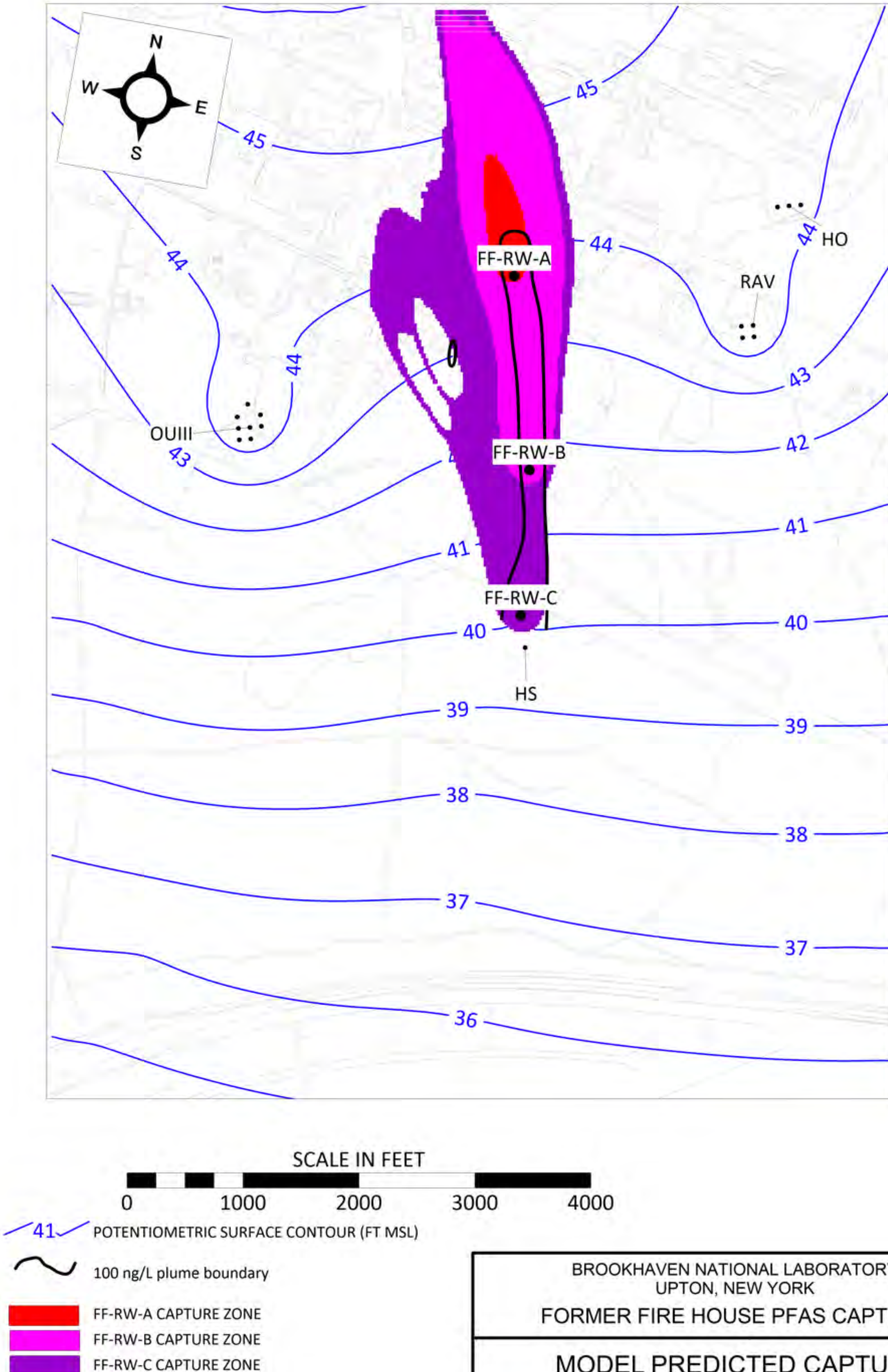
FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 5

ARCADIS Design & Consultancy for natural and built assets

FIGURE

9



PROJECT NAME -

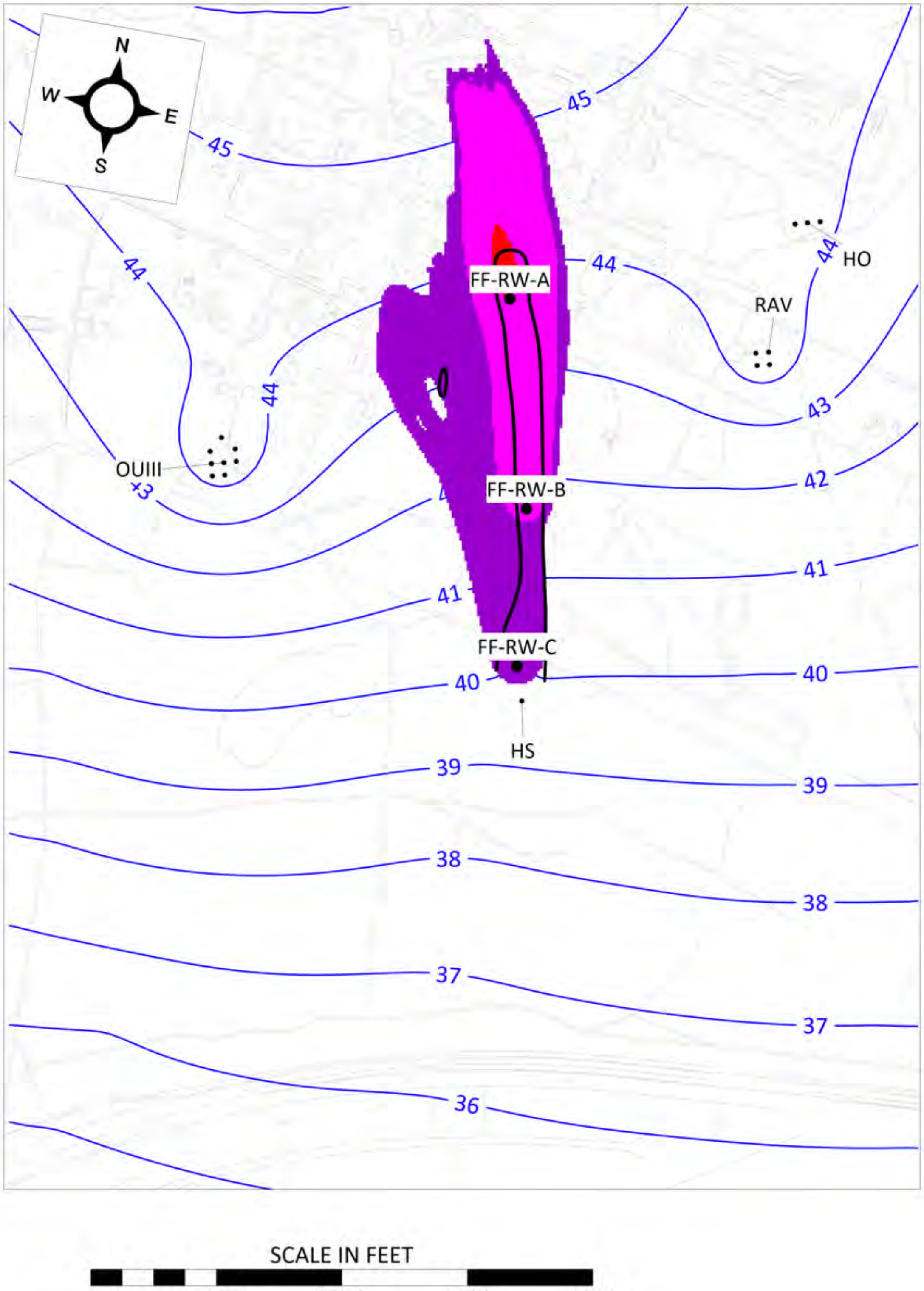
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 6

ARCADIS Design & Consultancy for natural and built assets

FIGURE
10



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

FF-RW-A CAPTURE ZONE

FF-RW-B CAPTURE ZONE

FF-RW-C CAPTURE ZONE

PROJECT NAME -

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

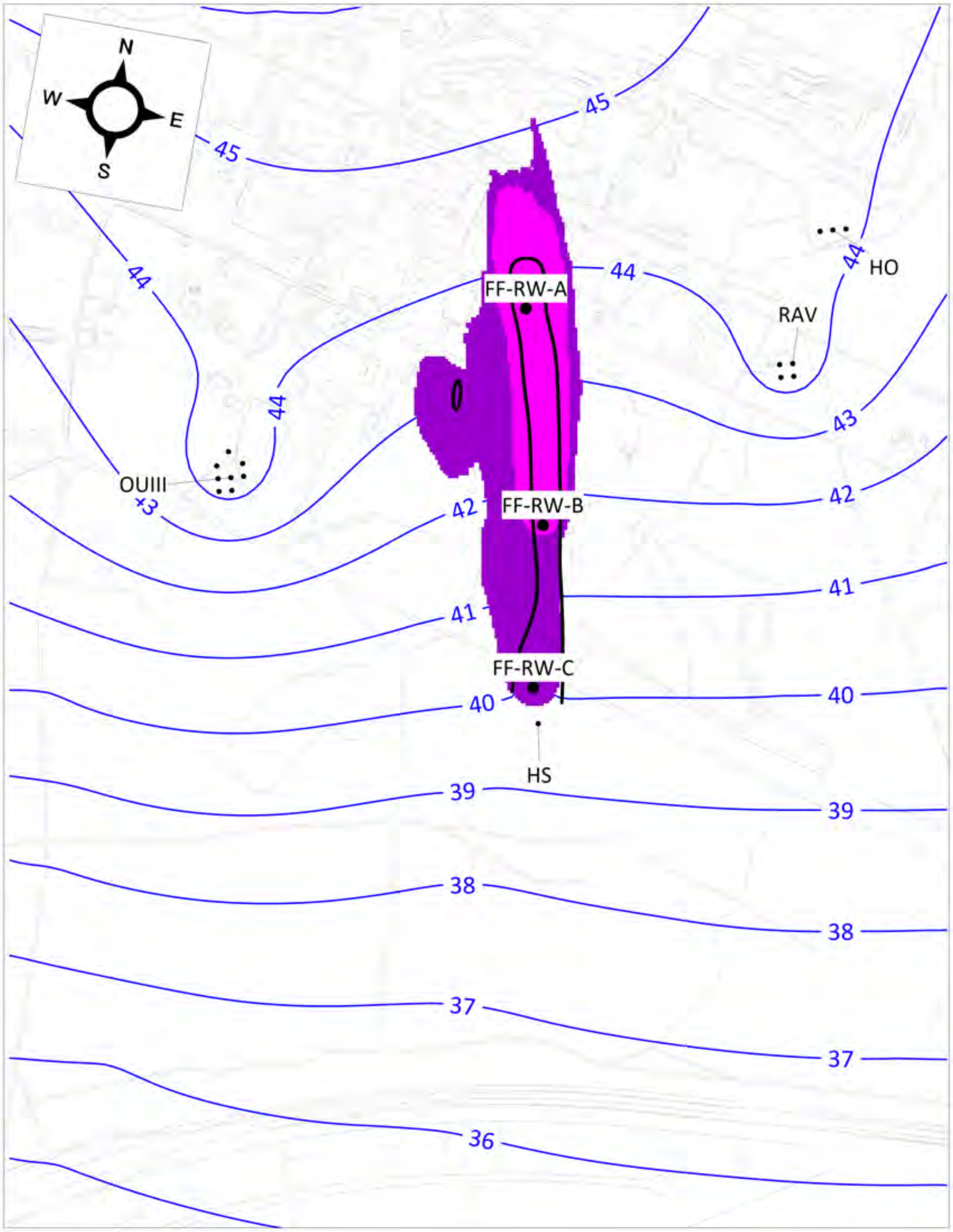
FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 7

ARCADIS Design & Consultancy for natural and built assets

FIGURE

11



SCALE IN FEET

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41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

FF-RW-A CAPTURE ZONE

FF-RW-B CAPTURE ZONE

FF-RW-C CAPTURE ZONE

PROJECT NAME -

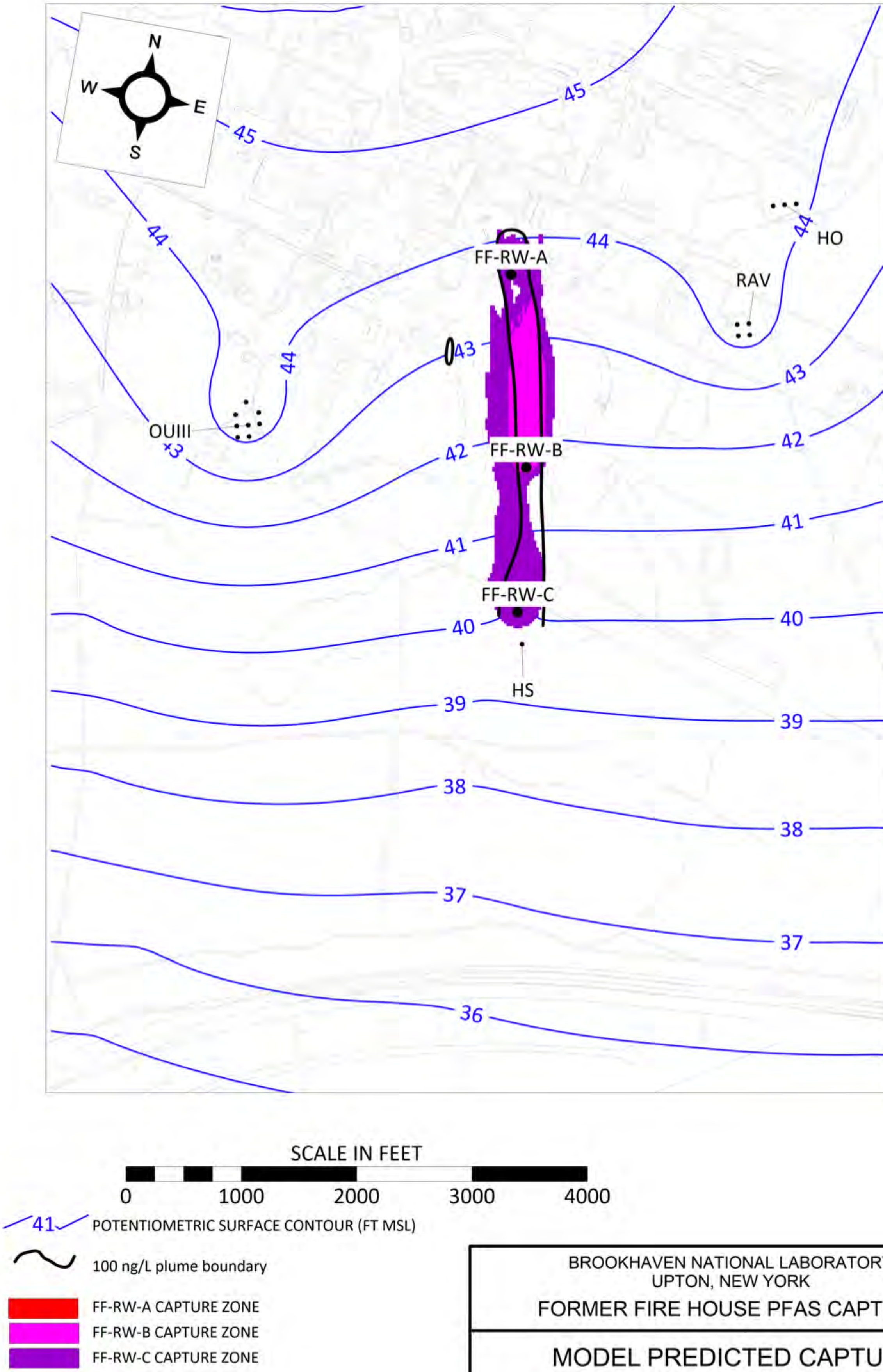
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 8

ARCADIS Design & Consultancy for natural and built assets

FIGURE
12



PROJECT NAME -

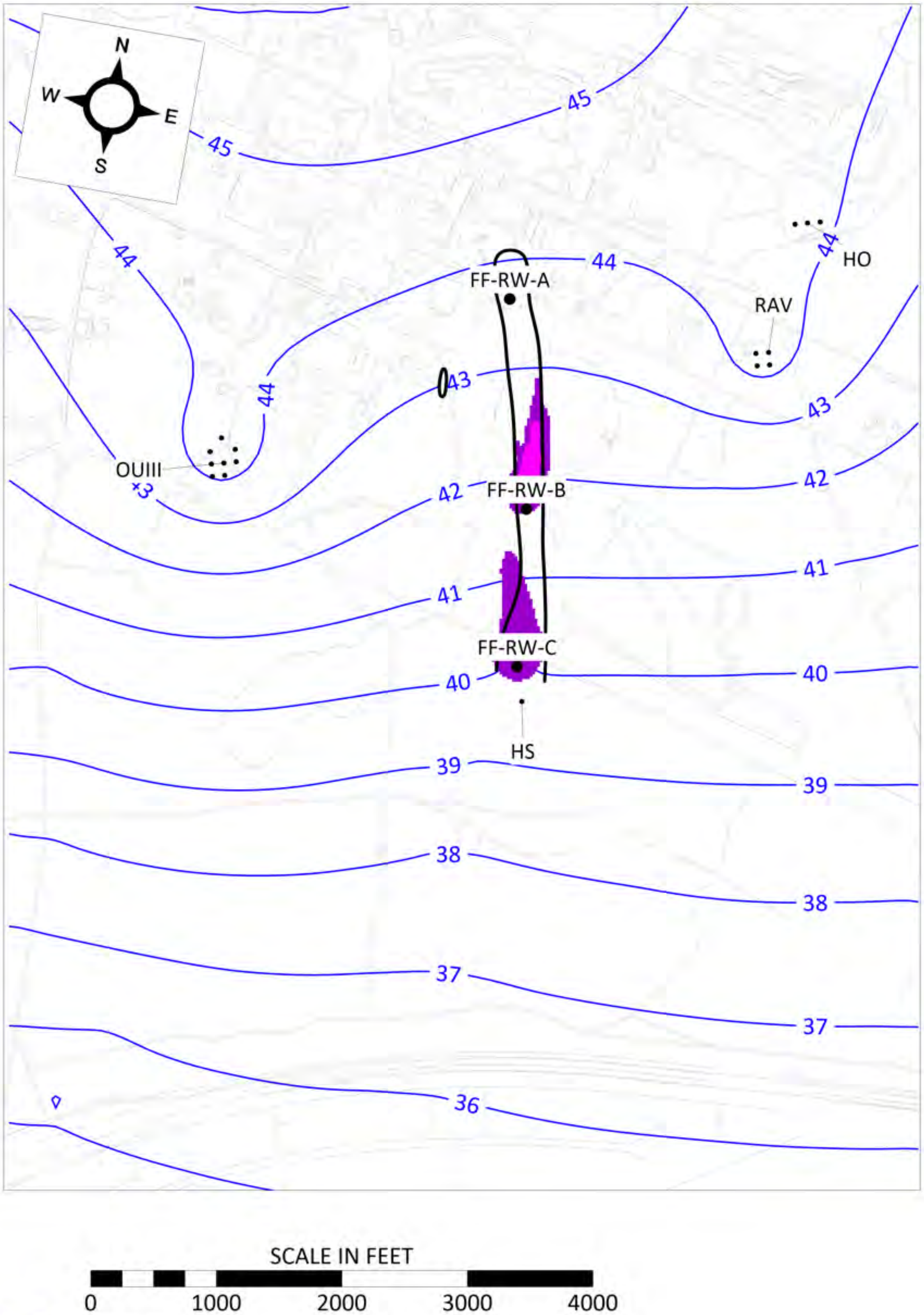
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 9

ARCADIS Design & Consultancy for natural and built assets

FIGURE 13



41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

FF-RW-A CAPTURE ZONE

FF-RW-B CAPTURE ZONE

FF-RW-C CAPTURE ZONE

PROJECT NAME -

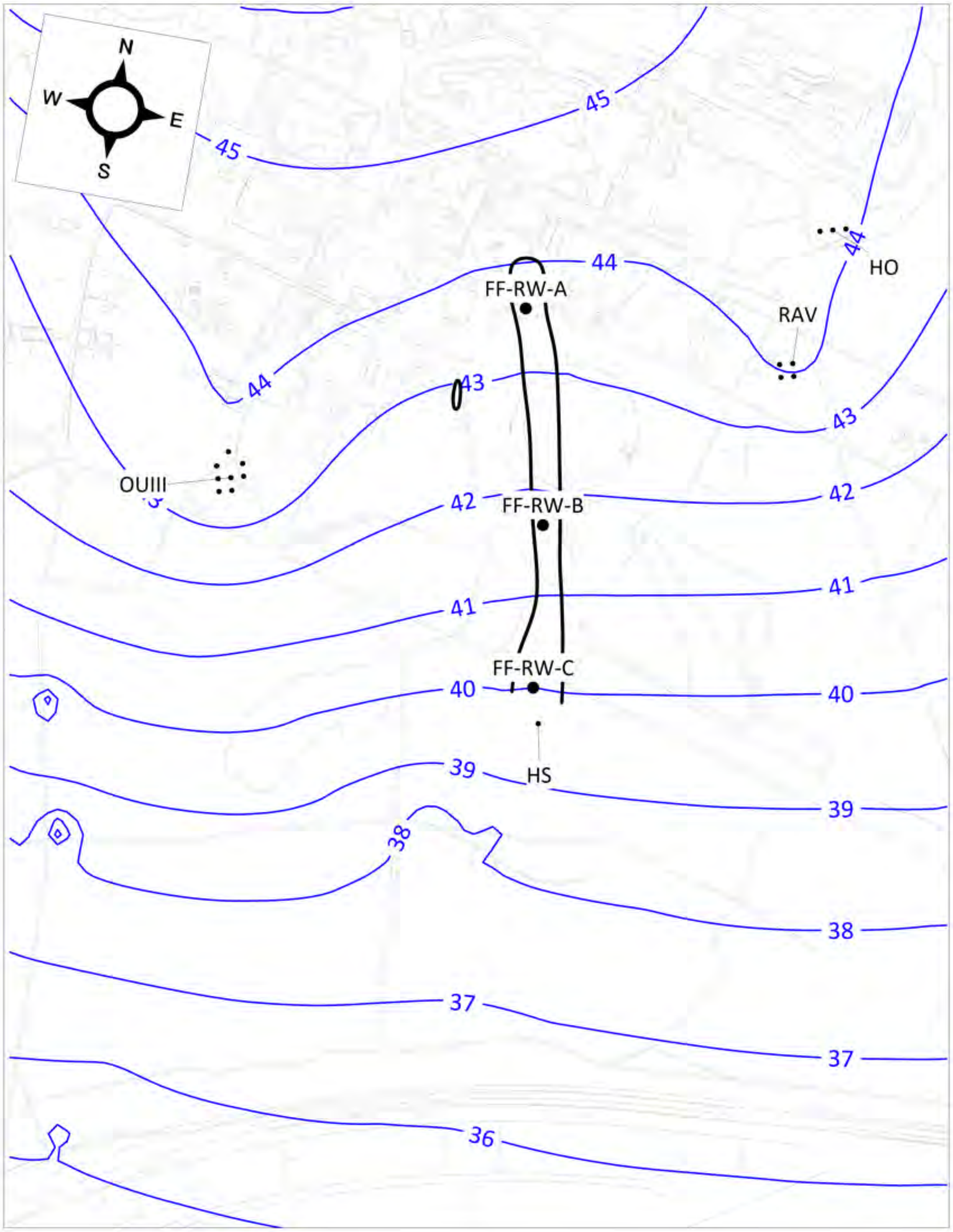
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

MODEL PREDICTED CAPTURE
MODEL LAYER 10

ARCADIS Design & Consultancy for natural and built assets

FIGURE
14



SCALE IN FEET

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41 POTENTIOMETRIC SURFACE CONTOUR (FT MSL)

100 ng/L plume boundary

FF-RW-A CAPTURE ZONE

FF-RW-B CAPTURE ZONE

FF-RW-C CAPTURE ZONE

PROJECT NAME -

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

FORMER FIRE HOUSE PFAS CAPTURE

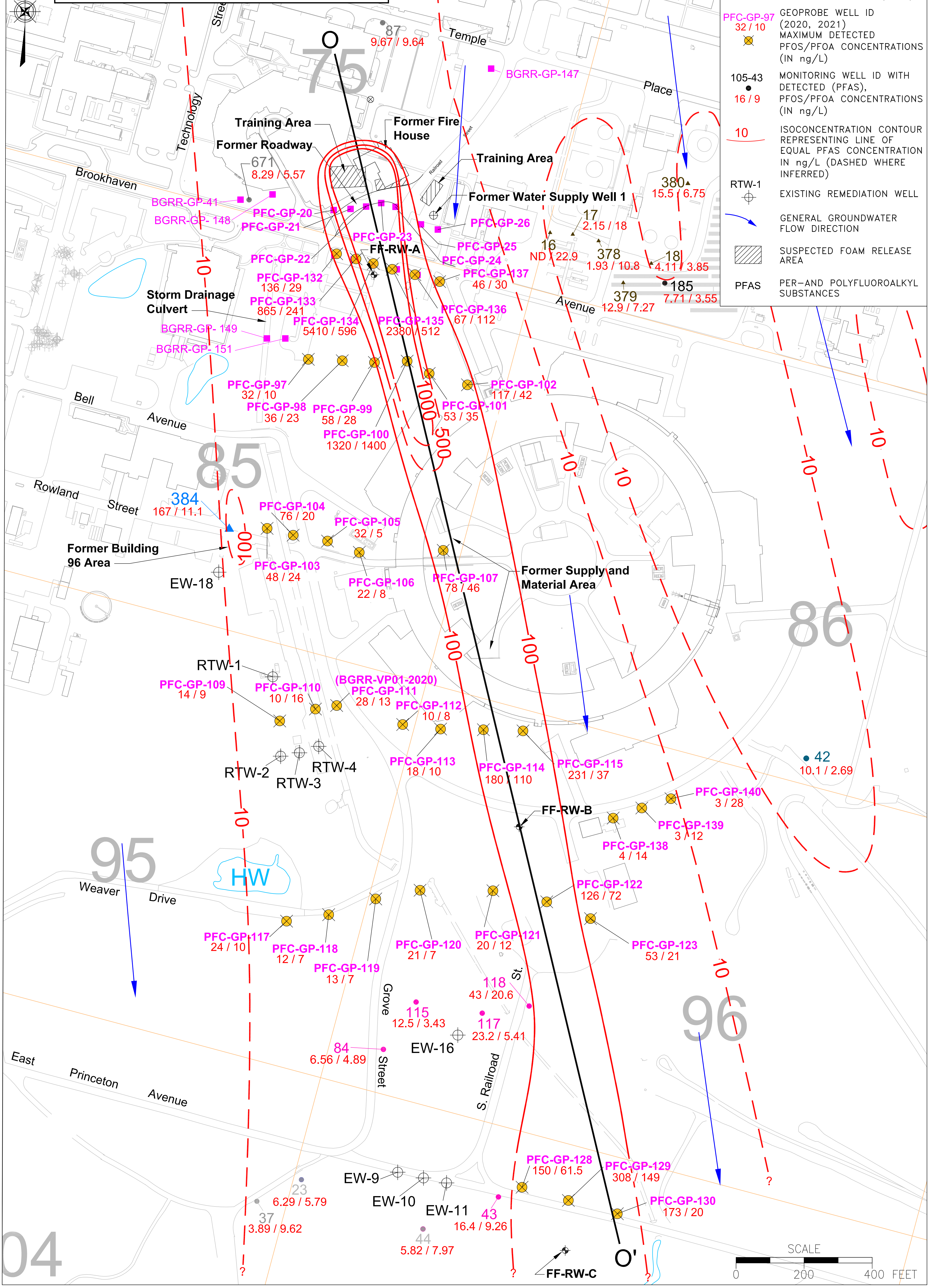
MODEL PREDICTED CAPTURE
MODEL LAYER 11

ARCADIS Design & Consultancy for natural and built assets

FIGURE

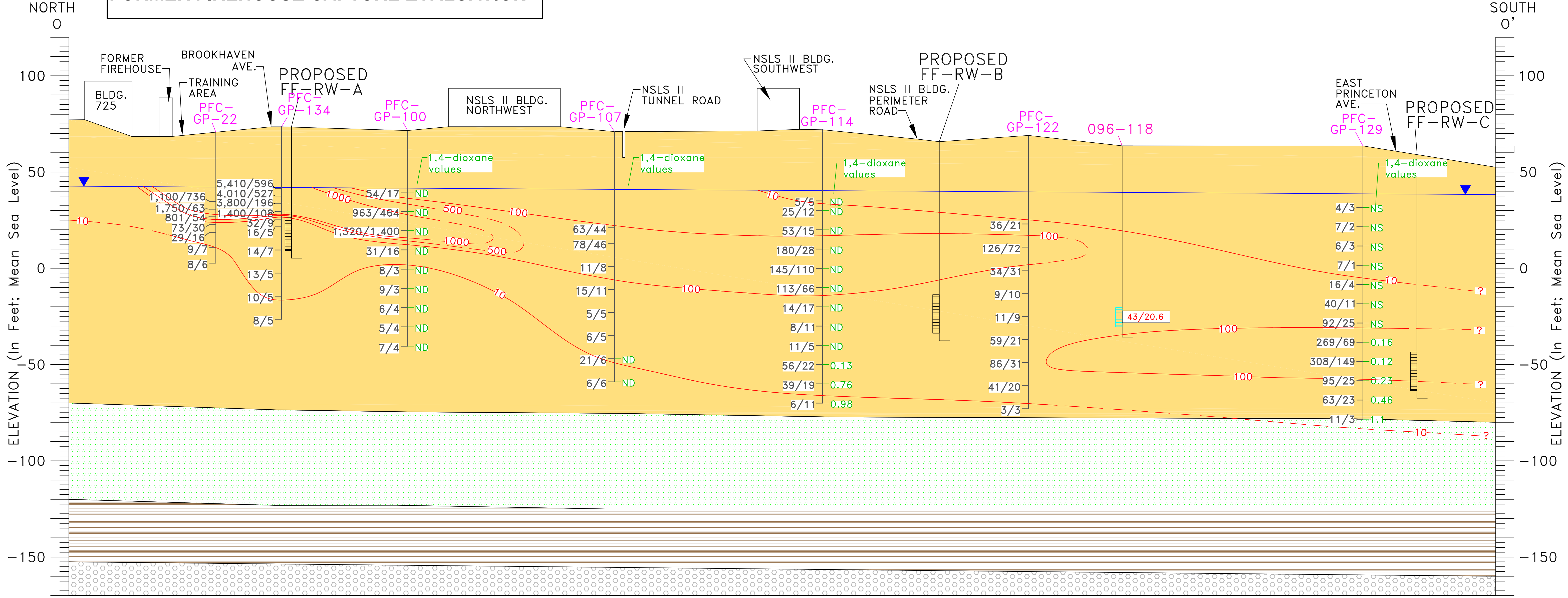
15

ATTACHMENT NO. 1
FOMER FIREHOUSE CAPTURE EVALUTION



BROOKHAVEN NATIONAL LABORATORY ENVIRONMENTAL PROTECTION DIVISION	TITLE: FORMER FIREHOUSE PFAS PLUME TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT	DWN: AJZ	VT: HZ.: –	DATE: 02/5/20	PROJECT NO.: –
		CHKD: DEP	APPD: DEP	REV.: 04/15/21	NOTES: –
		FIGURE NO.: 1			

ATTACHMENT NO. 2
FORMER FIREHOUSE CAPTURE EVALUATION



LEGEND

Upper Glacial aquifer

- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay

- GL Gardiners Clay
- GS Gardiners Clay – Silt

Magothy aquifer

- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undifferentiated)
- MO Magothy – OTHER

096-118 BNL Well ID

PFC-GP-22 Geoprobe Well ID

NS = Well Not Sampled

ND = Not Detected

ND/1.75 PFOS Value/PFOA Value in (ng/L)

—10— ISOCONCENTRATION CONTOUR REPRESENTING LINE OF EQUAL PFAS CONCENTRATION IN ng/L (DASHED WHERE INFERRED)

Water Table As Of Jan. 8 – Jan 10, 2020

Monitoring Well Screen

ng/L– Nanograms Per Liter

HORIZONTAL SCALE

0 500 FEET

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, CHARACTERIZATION REPORTS.

2) PFOS/PFOA RESULTS BASED ON JULY 13, 2020 – JANUARY 26, 2021 SAMPLING EVENTS.

3) CONTOUR INTERVAL IS AS SHOWN.

4) BNL WELL ID COLOR CORRESPONDS TO LONG-TERM MONITORING PROGRAM WELL LOCATION MAP.

Q:\2020\BNLab\20-01 EPD\Task 04 PFAS Characterization\Figures\Phase 5\2021-02-18\Fig_21 FF Section O-O' 021921.dwg

BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

FORMER FIREHOUSE CROSS SECTION O–O'
RESULTS FOR PFOS/PFOA

TIME CRITICAL REMOVAL ACTION, PFAS CHARACTERIZATION REPORT

DWN: AJZ	VT:HZ.: 20:1	DATE: 01/30/21	PROJECT NO.: –
CHKD: WRD	APPD: WRD	REV.: 04/15/21	NOTES: –
FIGURE NO.: 2			